BBC

THE HUNT FOR ALIEN WORLDS HITS A MILESTONE

#207 AUGUST 2022

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

DISCOVER PLANETARY NEBULAE

6 spectacular dying stars to seek out in late summer's night skies

SATURN RINGS TRUE

The Ringed Planet puts on a show at opposition

AN ASTRONOMER AT THE BOTTOM OF THE WORLD

12 ASTROPHOTO PITFALLS (AND HOW TO AVOID THEM)

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Welcome

Join our search for these summer showstoppers

Spread from west to east across the southern half of the sky in August are six of the most alluring planetary nebulae. They include the Helix Nebula, our cover image, pictured in infrared by the Spitzer Space Telescope and ultraviolet by GALEX. These curious objects are the remnants of stars like our own Sun, which have thrown off their outer layers in the final stage of their lives. Turn to **page 28** for Stuart Atkinson's tour and discover them for yourself.

The 18th-century astronomers who named these objects 'planetary' nebula were mistaken by the objects' appearance in the low-resolution telescopes of the time, but there's no mistaking the planets to have made it into the Exoplanet Archive. This definitive list of worlds outside the Solar System reached a milestone recently, when the 5,000th entry was confirmed. On **page 28**, Ezzy Pearson digs into the Archive to discover how representative it is of the overall population of planets in our Galaxy, and how the next milestone of 10,000 planets is set to arrive incredibly soon.

Turning to our Solar System's planets, on **page 48** read how Saturn with its magnificent rings reaches opposition around mid-month, putting in its brightest appearance for the current period of visibility. Some may bemoan its relatively low altitude (20°) and the bright Moon nearby when the planet reaches opposition on 14 August, but nevertheless, it still shines brightly all month and, with its ring angle still wide, this true wonder of nature is well worth taking a look at.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 11 August.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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The Sky Guide

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Georgina Dransfield

Telescope expert

"Lessons from an astronomer at the bottom of the world: don't underestimate the cold; do pack your favourite clothes." **Follow Georgina to Antarctica to upgrade an exoplanet-hunting telescope, page 66**

Mary McIntyre

Outreach astronomer

"It was amazing to be able to create a fully functional sundial from just two sheets of paper and a straw. This is a fun family project that provides many learning opportunities." **Mary shows us how it's done on page 74**

Stuart Atkinson

Astronomer

"Planetary nebulae are usually much fainter and smaller than other deep-sky objects, so they're often overlooked. But they're fascinating." **Take Stuart's tour around these dazzlers, starting on page 28**

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/RNFNUS4/** to access this month's selection of exclusive Bonus Content

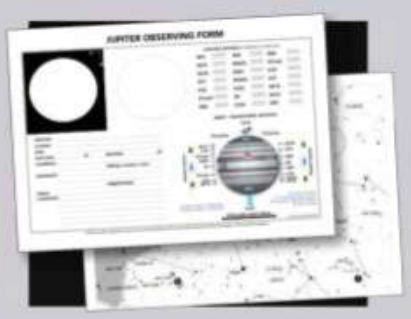
AUGUST HIGHLIGHTS

The Astronomer Royal at 80

In this special episode of *The Sky at Night*, Lord Martin Rees looks back on his illustrious career in astronomy.

Online interview: Solar System in X-ray

Astrophysicist William Dunn reveals how X-ray observations can uncover the secrets of the outer planets and their moons.



Download astronomy observing forms

Access and print out our report forms to help you keep track of your planetary and solar observing sessions.

The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

MANY SCOPES MAKE LIGHT WORK

Our neighbour in space, the Andromeda Galaxy, as we've seldom seen it before

MULTIPLE SOURCES, 16 JUNE 2022

This composite image contains data from ESA's Herschel and Planck telescopes, plus NASA's Infrared Astronomical Satellite (IRAS) and Cosmic Background Explorer (COBE).

From Earth, the Green Bank Telescope in West Virginia, the Westerbork Synthesis Radio Telescope in the Netherlands and the 30-metre IRAM (Institute for Radio Astronomy in the Millimeter Range) telescope in Spain also contributed. The need to blend the data comes from the fact that Herschel was only sensitive to far-infrared light and microwave radiation, meaning it missed around 30 per cent of the light given off by Andromeda's dust. Combining Herschel's data with that from other observatories gives a more complete picture of the light emitted by the galaxy.

Red in the image indicates hydrogen gas, green is cold dust, while blue shows dust that is warmer. At 2.5 million lightyears distant, the Andromeda Galaxy (or Messier 31) is 220,000 lightyears across.

MORE **ONLINE**

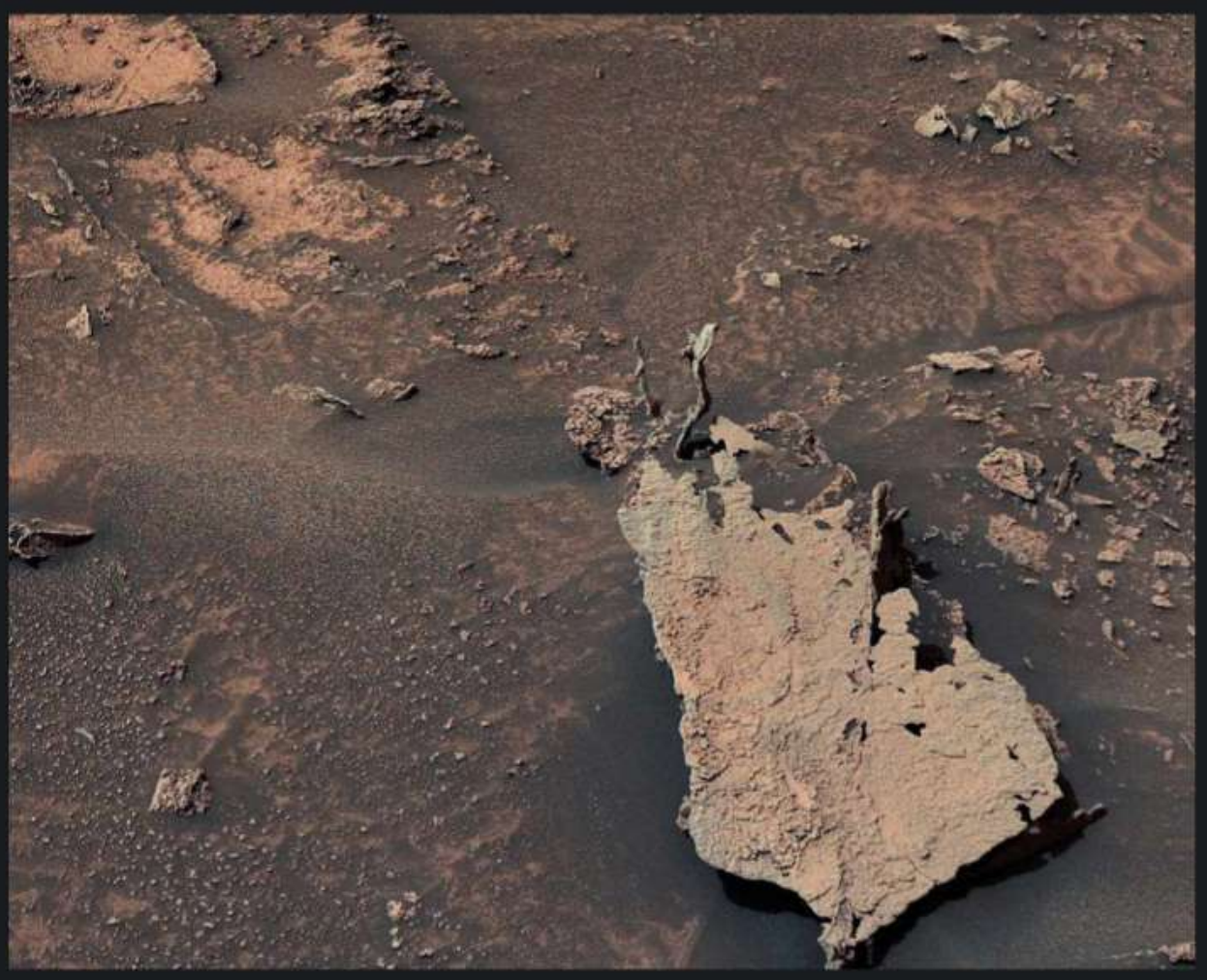
Explore a gallery of these and more stunning space images

ESA/NASA/JPL-CALTECH/GBT/WSRT/IRAM/C. CLARK (STSCI)

△ Asteroids in Gaia data

GAIA SPACE OBSERVATORY, 13 JUNE 2022

The yellow dot at the centre of this image is the Sun and everything else represents the orbit of asteroids around it – over 150,000 of them. Blue is the inner Solar System, the Main Belt is green, while Jupiter's trojan asteroids are red.



Fingers from Mars ▷

CURIOSITY ROVER, 15 MAY 2022

Likely formed by groundwater trickling through rock and depositing minerals, these strange finger-like rocks were spotted by the Curiosity Rover on Mars. When the rocks were exposed to the wind, it eroded away the softer portions, leaving strange shapes behind.

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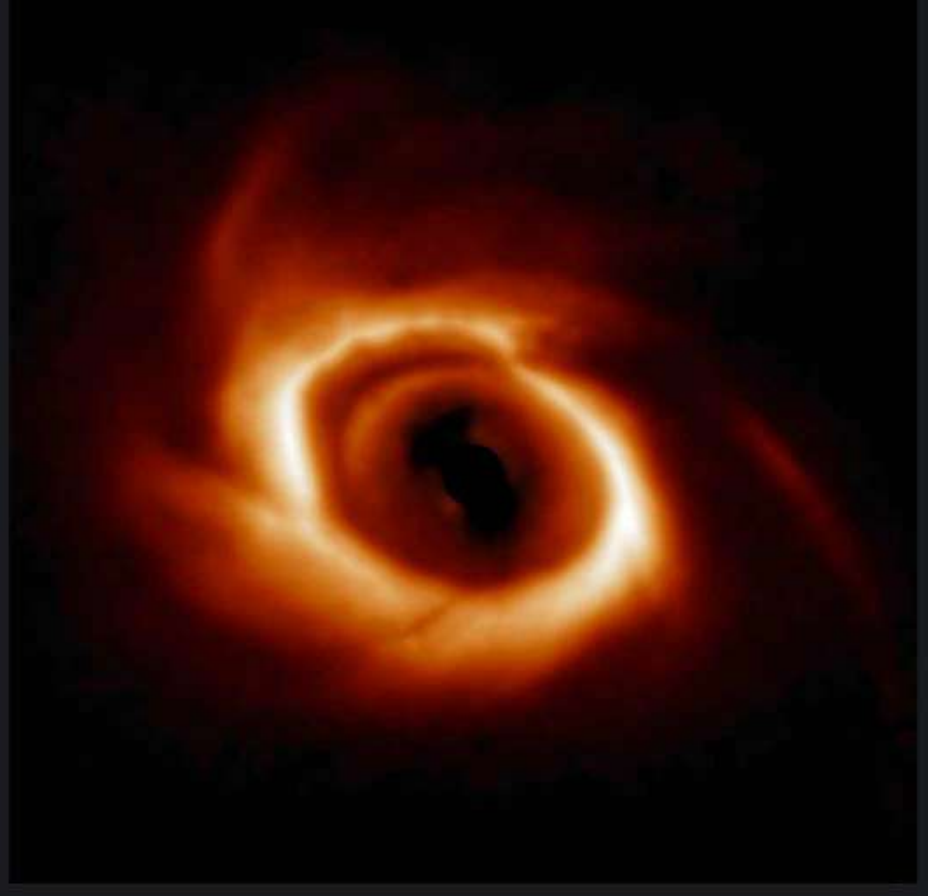

◁ Dusty disc

GEMINI SOUTH, 15 JUNE 2022

HD 34700 A, in the constellation of Orion, the Hunter, is surrounded by a swirling disc that's likely to become a new planetary system. The image was taken with the Gemini Planet Imager (GPI) instrument on the Gemini South telescope, Chile.

▽ Clustered galaxies

HUBBLE SPACE TELESCOPE, 20 JUNE 2022

This is galaxy cluster Abel 1351, four billion lightyears away in Ursa Major, imaged by the Hubble Space Telescope. The streaks are the gravitationally-lensed images of distant galaxies, their light bent by the presence of the massive galaxy cluster.

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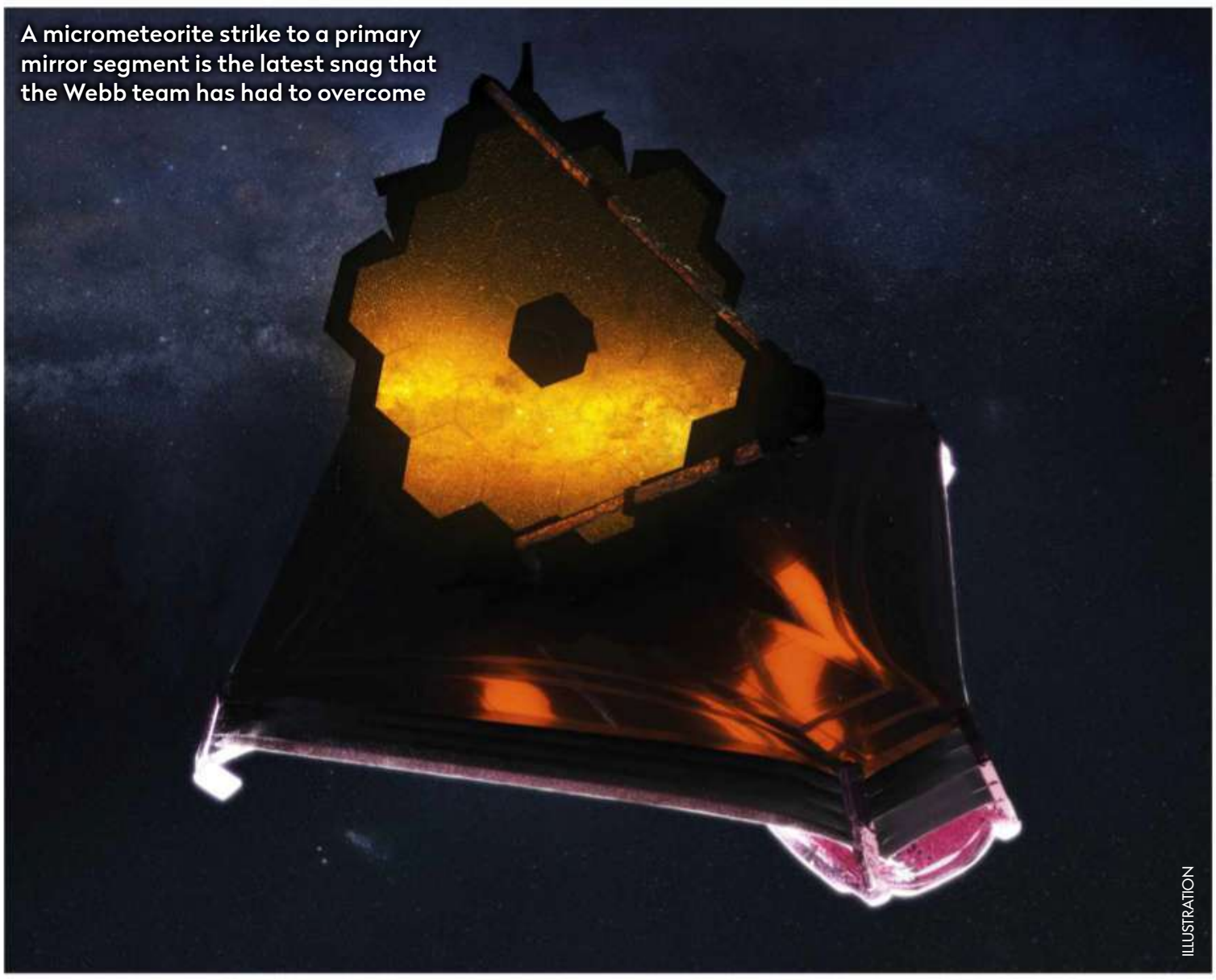


A micrometeorite strike to a primary mirror segment is the latest snag that the Webb team has had to overcome

ILLUSTRATION

ADRIANA MANRIQUE GUTIERREZ/NASA ANIMATO

Countdown to Webb's first images

After numerous hitches, the 6.5m telescope is finally ready to observe

After six months of travelling, unfolding, calibrating and double checking, the James Webb Space Telescope is now fully operational and ready to begin exploring the infrared Universe. By the time you're reading this, the first science images should have already been released to the public, a first glimpse at what promises to be a deluge of discovery.

If all goes to plan, the telescope will release its first 'teaser suite' of images on 12 July to demonstrate its capabilities before entering its full science phase.

"As we near the end of preparing the observatory for science, we are on the precipice of an incredibly exciting period of discovery about our Universe," says Eric Smith, Webb's program scientist. "The release of Webb's first full-colour images will offer a unique moment for us all to stop and marvel at a view humanity has never seen before."

However, the path to this point hasn't been completely without hurdles. Between 23 and 25 May, the 6.5m wide primary mirror was struck by a micrometeorite larger than any it had been tested to withstand. Initial tests found it did have a small effect on the telescope's data, though the Webb team have been able to partially cancel out the effects by adjusting the mirror positions. Even with the damage, the high level of engineering on Webb means it is operating with a greater precision than it was initially designed for, leaving astronomers the world over eagerly waiting to see what images it will be able to produce.

"These images will be the culmination of decades of dedication, talent and dreams," says Smith. "But they will also be just the beginning."

www.jwst.nasa.gov

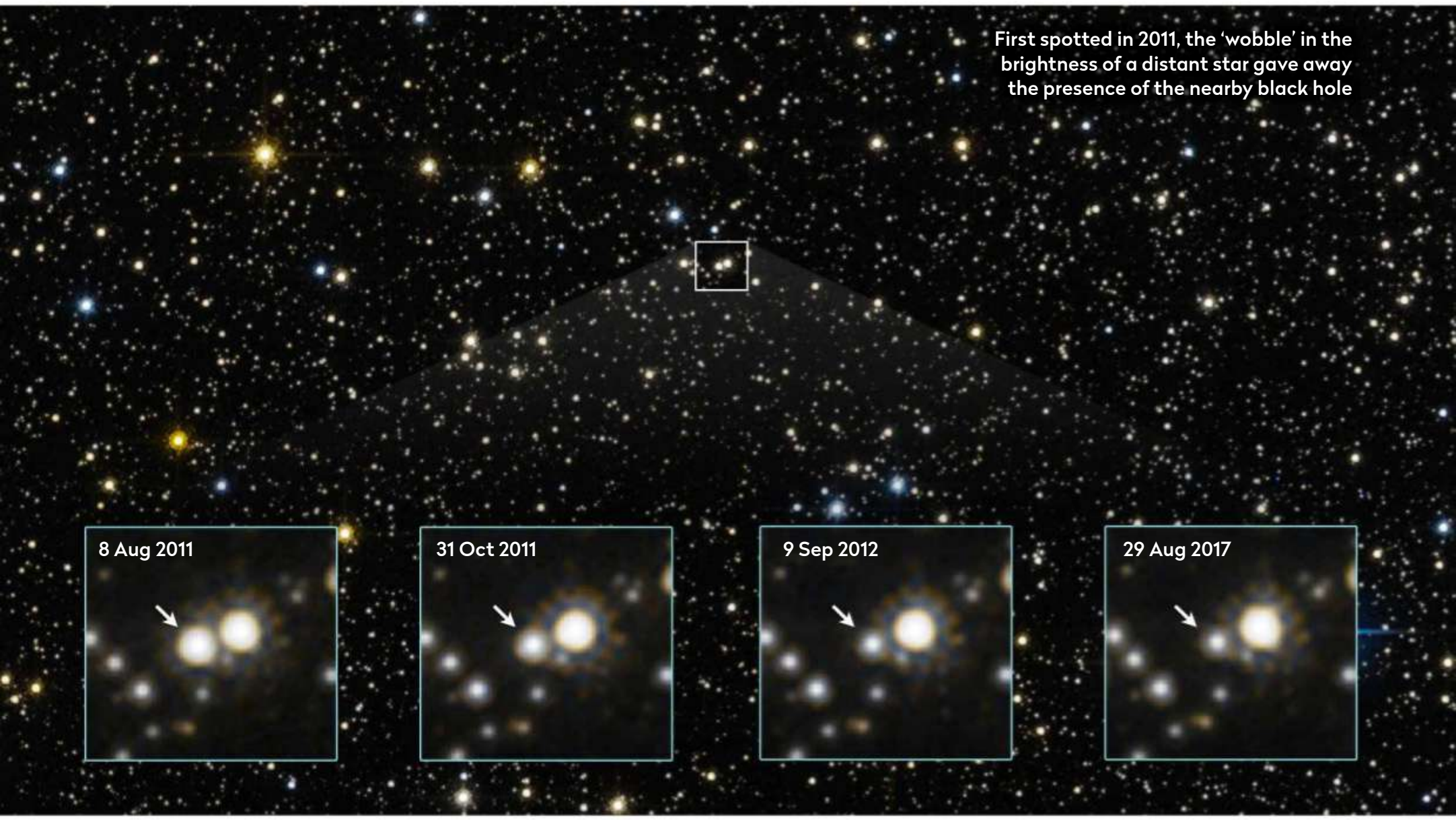
Comment

by Chris Lintott

A critical milestone went by almost unnoticed in June, as JWST's first observations started to be executed by the observatory – the point when science started to flow from astronomy's new toy.

All over the world, astronomers are getting to grips with how to make the best of what JWST is sending them. Some have been planning for decades for this moment. Work continues to allow access to more advanced modes of operation, but it's remarkable to have reached this point already. As someone close to the commissioning team told me, they planned for what seems to have happened: everything going right. The reward for that hard work is about to arrive.

Chris Lintott co-presents *The Sky at Night*



First spotted in 2011, the 'wobble' in the brightness of a distant star gave away the presence of the nearby black hole

NASA/ESA/KAILASH SAHU (STSCI)/JOSEPH DEPASQUALE (STSCI), PSYCHE SCREENSHOT COURTESY OF NASA, ALMA (ESO/NAOJ/NRAO)/T. WONG (U. ILLINOIS/URBANA-CHAMPAIGN)/S. DAGNELLO (NRAO/AUI/NSF), MELISSA WEISS/NRAO/AUI/NSF

Hubble uncovers a lone black hole

Wandering singularity discovered through microlensing as it warps distant starlight

The Milky Way is filled with the ghosts of dead stars. Our Galaxy is thought to be home to some 100 million black holes, the final chapter in the lives of large stars, but tracking down these elusive objects is difficult as they emit no light and can only be found through their effect on the surrounding environment.

However, after six years of painstaking observations, the Hubble Space Telescope has uncovered what appears to be a lone black hole floating through space and has measured its mass, giving the first ever direct evidence of a dark stellar remnant that's unaccompanied by stars or an accretion disc.

The black hole was found using a technique known as microlensing, when light from a distant background star is deflected by the gravity of a foreground object. Because of this, chance alignments cause the background star's brightness to fluctuate. These alignments are rare, but if a telescope is pointed at enough stars for a long time, it should eventually see a tell-tale wobble in the background star's brightness, revealing an otherwise invisible object.

"Astrometric microlensing is conceptually simple but observationally very tough," said Kailash Sahu from the Space Telescope Science Institute, who led one of two teams investigating the discovery. "Microlensing is the only technique available for identifying isolated black holes."

Sahu's team used the pattern of changing brightness to estimate the black hole is around seven solar masses. However, another team led by Casey Lam from the University of California, Berkeley, measured it to be between 1.6 to 4.4 solar masses. While the top end of that range would indeed be a black hole, the lower end would be a neutron star.

"Whatever it is, the object is the first dark stellar remnant discovered wandering through the Galaxy unaccompanied by another star," says Lam.

The discovery proves the validity of using microlensing to find black holes and helps provide insight into how common they are within our Galaxy. Using the data from this investigation, the team predicted that the nearest lone black hole to Earth is probably around 80 lightyears away.

In the coming years, new telescopes such as the Nancy Grace Roman Space Telescope will discover hundreds more black holes in the same way. Our journey to understanding these mysterious objects is just beginning.

hubblesite.org

ILLUSTRATION

The Psyche mission is the first to take a close look at a planet's metallic core

Psyche map reveals varied surface

Uncovering the asteroid's origin could show us how planets form

The asteroid Psyche has a surprisingly diverse landscape, according to a new set of maps that give a more detailed view of its surface than ever before. They were created ahead of a mission to explore the asteroid up close, also called Psyche, which is due to launch later this year.

The asteroid Psyche is believed to have originated in the core of an infant planet that was later destroyed, and as such it gives a glimpse at part of a planet usually hidden from view. It is rich in metals, but these new maps show there are also several rocky areas – most likely originating from the mantle – and large depressions filled with sand.

"It's an evolved surface and these maps confirm that metal-rich asteroids are interesting, enigmatic worlds," says Saverio Cambioni from MIT, who led the study. "It's another reason to look forward to the Psyche mission going to the asteroid."

psyche.asu.edu/

Gravity holds strong in turbulent star nursery

The star-forming region of 30 Doradus in the Large Magellanic Cloud is a roiling region of very bright, intense star creation. Having given rise to more than 800,000 stars and protostars, researchers look towards it to understand the complex interaction of gravity pulling gas together to form stars, and the energy released by young stars that pushes gas away, known as feedback.

However, a new study using data from the Atacama Large Millimeter/Submillimeter Array has turned up a surprising find.

"We were expecting to find that the parts of the cloud closest to the young, massive stars would show the clearest signs of gravity being overwhelmed by feedback and, as a result, a lower rate of star formation," says Tony Wong from University of Illinois, who led the research. "Instead, these observations confirmed that even in a region with extremely active feedback, gravity's presence is still strongly felt and star formation is likely to continue."

Stellar feedback unexpectedly appears to not stifle new star formation in 30 Doradus

Astronomers will continue to study the region, attempting to uncover what makes 30 Doradus so prolific at creating stars compared to other star formation regions within the Milky Way.

www.almaobservatory.org

NEWS IN BRIEF

ILLUSTRATION

Baby neutron star

Astronomers may have found the youngest known example of a neutron star. Located in a dwarf galaxy 395 million lightyears away, it does not appear in images taken in 1998, but is in observations taken from 2018 onward, suggesting it appeared in the interim.

Dying stars forge complex carbon

Dying stars could forge tiny cylinders made of carbon atoms, known as nanotubes, which were discovered in the interstellar medium decades ago. Researchers in a lab subjected silicon carbide (which is commonly found around dead stars) to conditions found around stars in their final stages of life and found that it formed the rod-like structures.

Fire at Kitt Peak

A wildfire passed by the Kitt Peak National Observatory in Arizona in late June, destroying four support buildings, though it did not reach the 23 telescopes. At time of writing it was still too dangerous to determine if any of the telescopes were damaged, but they will remain inoperable until infrastructure such as the power supply is repaired.

NEWS IN BRIEF

SOUTHWEST RESEARCH INSTITUTE, NASA/ESA/HUBBLE/R. HUMPHREYS/UNIVERSITY OF MINNESOTA/J. OLMSTED/ STSCI, NASA/JPL-CALTECH/B. JÖNSSON

Lucy continues on

NASA has announced that the Lucy spacecraft can complete its mission, despite failing to deploy and latch its solar panels properly after launch in October 2021. Lucy will continue on to the orbit of Jupiter, where it will study the Trojan asteroids that can be found there.

Mysterious blue blobs

A novel class of lonely, irregularly distributed collections of stars has been newly identified. Closer inspection of five 'blue blobs' has revealed they are similar to dwarf galaxies, but appear to have no parent galaxy. The nearest examples to Earth are some 300,000 lightyears away.

Gaia's third data release

ESA's Gaia satellite has released its third batch of data, giving updated measurements of the age, composition, temperature and motion of over two billion stars. The data has also yielded unexpected discoveries, such as detecting starquakes on stellar surfaces – something it wasn't designed to do.

BULLETIN

Capturing the death of a giant

The image throws light on the final days of giant stars

The violent death throes of rare hypergiant star VY Canis Majoris have been captured in a new 3D image. The model, created using data from the Atacama Large Millimeter/Submillimeter Array (ALMA), shows the motion of gas surrounding the star in unprecedented detail.

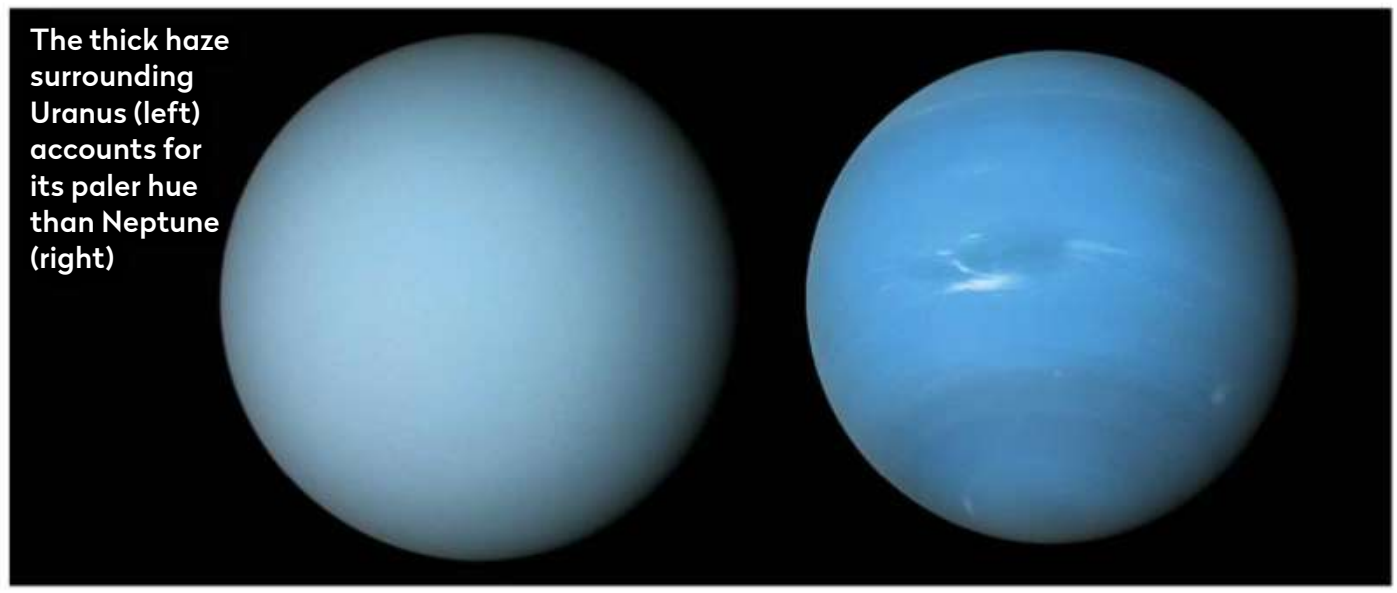
VY Canis Majoris is one of only a few known red hypergiants. Unlike lower-mass stars, which retain their spherical shape during their red giant phase, these goliaths sporadically belch out material, forming complex, irregular structures.

"Until now, only small portions of this enormous structure had been studied, but you can't understand the mass loss and how these big stars die unless you look at the entire region," says Lucy Ziurys from the University of Arizona, who led the study. "That's why we wanted to create a complete image."

www.almaobservatory.org

▲ The new 3D model shows how red hypergiant VY Canis Majoris loses mass as it nears death

Mystery of pale Uranus solved



The thick haze surrounding Uranus (left) accounts for its paler hue than Neptune (right)

The atmospheres of Uranus and Neptune are remarkably similar in composition, consisting of mostly hydrogen, with some helium and a little methane, which gives them both their blue colour. Yet despite this, the two planets are noticeably different in hue, with Neptune a deep royal blue while Uranus is a pale turquoise. After years of wondering what could be causing the difference, a new set of observations from the Gemini Observatory might finally explain it.

By looking at the planets in many wavelengths, astronomers were able to observe the different layers of the two planets' atmospheres. Both are covered by a layer of haze, which the new study found extends much deeper than previously thought. It also showed that Uranus's haze is much thicker, effectively whitening the planet.

"We hoped that developing this model would help us understand clouds and hazes in the ice giant atmospheres," commented Mike Wong from the University of California, who took part in the study. "Explaining the difference in colour between Uranus and Neptune was an unexpected bonus."

www.gemini.edu

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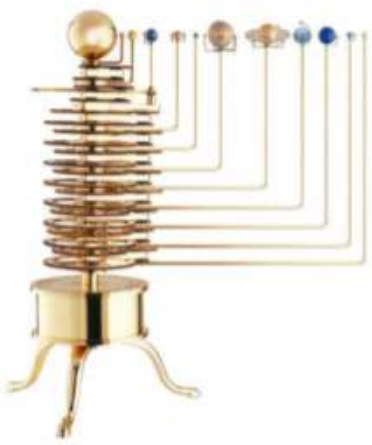
Inspired by the original Orrery and the classical scientific instruments of the seventeenth and eighteenth centuries, this mechanical model of the solar system is not only a work of art, but a functioning model of the solar system as it is known in the time that we are living. When complete, this beautiful model stands 37cm high with a span of 60cm at its widest point – a truly impressive museum-quality statement piece to display and use in your own home.

This unique design features an exposed gear train that controls the speed and ratio of the orbits of the planets as they move around the sun. Made from solid brass, the gears and hand-polished and lacquered to minimise tarnishing.

Fashioned from silver-plate, your planets are hand painted to capture the nature and defining characteristics of the real planets.

An Original Design

The solar system model is adapted from an original 1980s design by British engineer, inventor and metal worker Louis Calmels. This version was first created in 2008 and and was endorsed by Sir Patrick Moore who said "This Orrery is attractive and accurate and I heartily recommend it".



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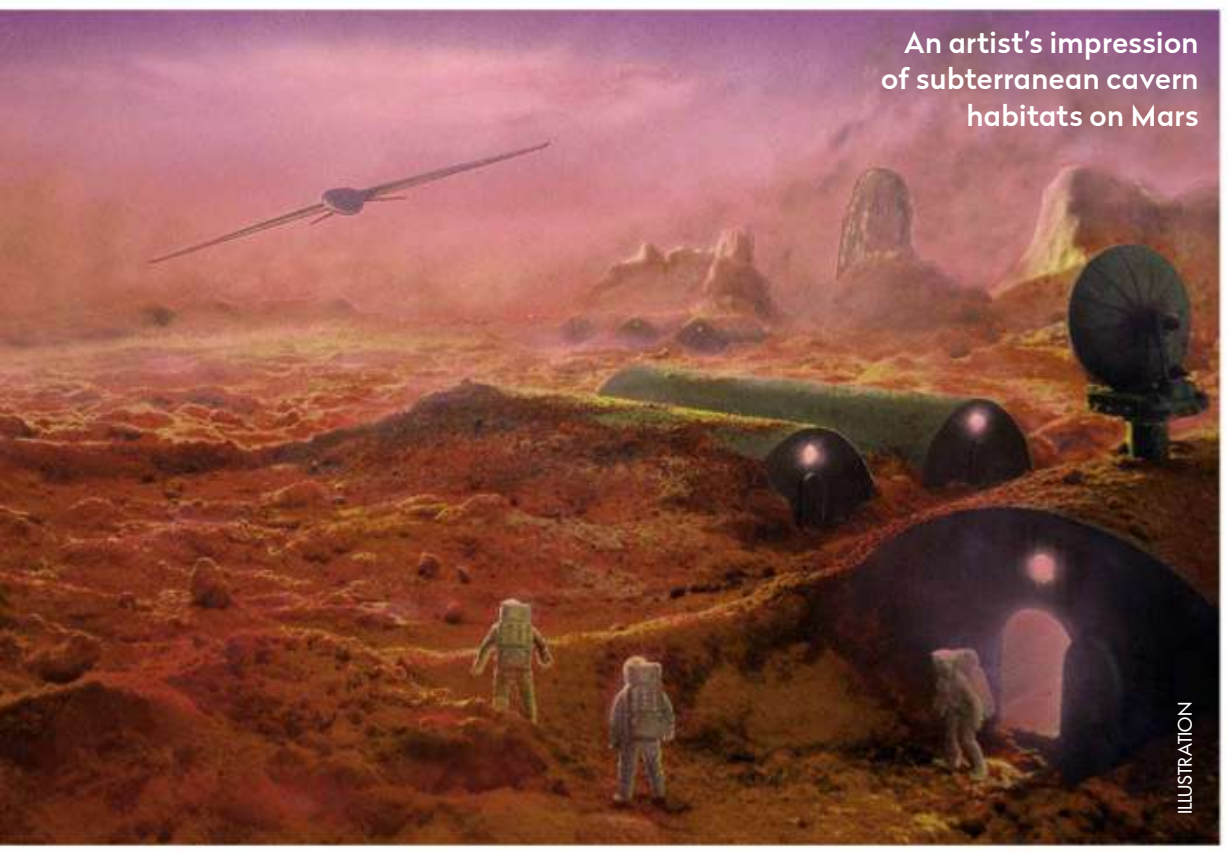


An artist's impression of subterranean cavern habitats on Mars

ILLUSTRATION

How to hide from radiation on Mars

Could Martian 'hobbit holes' protect future colonists from deadly radiation?

Crewed missions into deep space will face a variety of different hazards. During the interplanetary transit on a mission to Mars, for example, the astronauts will spend around nine months in weightlessness. Without the constant loading of gravity, the body's muscles waste away and the heart weakens as it no longer has to pump blood 'uphill'. The skeleton also becomes more fragile and long-duration astronauts can face osteoporosis, and the calcium leaching out of their bones can cause kidney stones. There's also the ever-present risk of equipment failure – problems with life support systems could spell doom for a mission.

On top of all this is the danger presented by cosmic rays. Outer space is filled with fast-moving subatomic particles thrown out by the Sun during a coronal mass ejection or accelerated to extremely high energies by supernovae throughout the Galaxy. When such radiation particles strike a cell, they can cause a great deal of molecular damage, including creating mutations in the DNA and triggering cancer.

There is a lot of interest in trying to understand the risks posed by cosmic radiation for astronauts on the surface of Mars and how best to protect them from this harmful bombardment. The Earth has a substantial magnetic field that deflects a lot of charged particles and our thick atmosphere absorbs most of the cosmic radiation before it can reach the surface. But Mars has neither and astronauts would be dangerously exposed. Dionysios Gakis at the University of Patras, Greece, and his colleague Dimitra Atri have been using computer models to study how best a crew might be protected.

Going underground

One method is active shielding. For example, superconducting electromagnets could be used to create a powerful magnetic field to deflect the incoming charged radiation particles away, just as Earth's field does. The problem is that such solutions can demand a lot of power to run and the technology is a long way from being fully developed. An easier alternative is passive shielding: simply placing a thick bulk of shielding material between the crew habitat and the sky.

"Hydrogen is the best shielding material, so tanks of rocket fuel or water could double up as radiation shields over crew quarters"

Gakis and Atri consider a variety of different materials. Aluminium – the metal that spacecraft are constructed from – is actually a pretty bad radiation shield. When hit by an energetic cosmic ray, its atoms can shatter and fly onwards to create even more radiation particles. Martian regolith suffers from the same problem, but it is abundantly available and would reduce the amount of material needing to be launched from Earth. A crew habitat could be buried beneath a 2–3m layer to re-absorb these secondary radiation particles. Gakis and Atri note that hydrogen is the best shielding material, as its light atoms don't create as much secondary radiation, and so tanks of rocket fuel or water placed over crew quarters could double up as effective radiation shields. Or hydrogen-rich plastics like polyethylene could be used to cement regolith grains together and improve their shielding effect.

Personally, I love the mental image of Mars astronauts living in habitats buried within an artificial hill of Martian soil, like an extraterrestrial hobbit hole!

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Modelling the Effectiveness of Radiation Shielding Materials for Astronaut Protection on Mars* by Dionysios Gakis and Dimitra Atri **Read it online at: https://arxiv.org/abs/2205.13786**

JULIAN BAUM/SCIENCE PHOTO LIBRARY, 7ACTIVESTUDIO/ISTOCK/GETTY IMAGES

Keeping cool when you're a white dwarf

New research reveals that the slow cooling of white dwarfs is far more complex than it first appears

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

White dwarfs have always struck me as, well, a little dull. Compared to the neutron stars and black holes produced by more massive stars at the end of their lives, the fact that our Sun will end its days as a 'mere' white dwarf seemed slightly disappointing. These stellar embers come across as simple, doing little but cooling and fading during their long afterlives.

It turns out that's nonsense. Dense balls of matter held up by weird complex effects, created in the maelstrom at the end of a star's life, it shouldn't be a surprise that white dwarfs are as complex and fascinating as any other star. This month's paper, from a Canadian–American team, sheds light on some of the weirder members of the white dwarf family.

The best way to understand stars is to make a Hertzsprung-Russell diagram, plotting the colour (or temperature) against brightness. In such a diagram, stars like the Sun form a distinct line, known as the 'main sequence', which stretches from bright, hot blue stars at one end to faint, cool red dwarfs at the other. Off to one side, however, are the white dwarfs which are on the blue-to-white end, but faint. Yet it turns out that the white dwarfs are not just scattered randomly across their bit of the diagram.

Cooling-off period

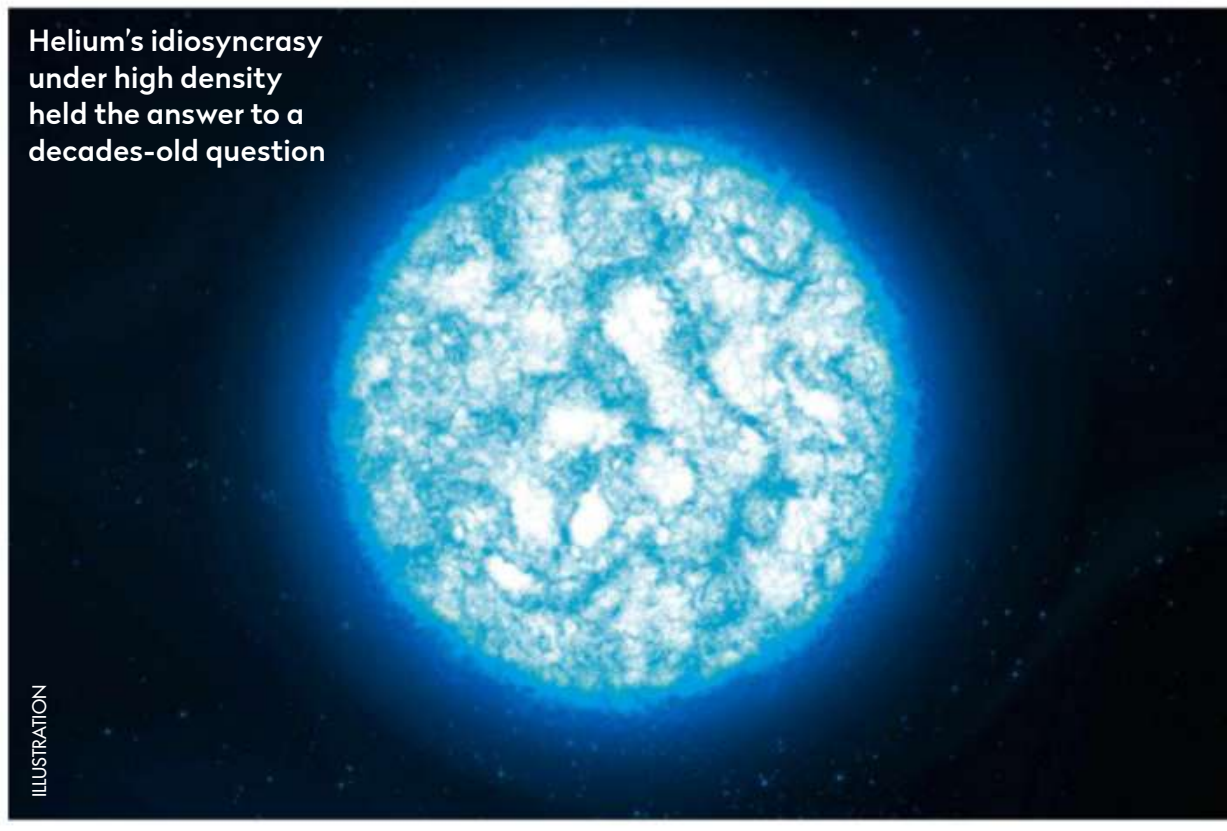
If you're a white dwarf, your main activity is to spend time cooling down. How you do that depends on your age and state. Early on, the white dwarf efficiently loses energy by radiating, but later on things become more complicated. The sample studied here, for example, seems to be cooling via a process which involves collisions between hydrogen and helium in their atmospheres.

White dwarf atmospheres are deeply odd, forming a thin layer around the surface of the star. If the Earth had such an atmosphere, the largest skyscrapers would stick out of the top. In such circumstances, collisions between atoms and molecules are common. When molecules collide, they can radiate, releasing energy, and a set of white dwarfs are believed to use this method to become ultracool white dwarfs.

The trouble was that using this effect to explain the position of these ultracool dwarfs in the HR diagram failed to match their observed temperatures. The great breakthrough of this work – solving a problem that has bothered astronomers for decades – is to realise that helium ions behave differently at the densities reached in the dense but narrow atmosphere of a white dwarf. It's a good example of why studying these places is interesting: they make us think about conditions that don't exist elsewhere and test our theories.

> ***"The great breakthrough is to realise that helium ions behave differently at the densities reached in the atmosphere of a white dwarf"***

Correcting the effect of helium ions on the atmosphere makes everything work. The white dwarfs in question are more massive than we thought, perhaps nearly as massive as the Sun, and they sit neatly on the HR diagram. The only problem is explaining where the hydrogen in the ones with the most massive atmospheres comes from. One possibility is that they've accreted it from in-falling asteroids, comets and even planets – further proof that life for white dwarfs is far from boring.



Helium's idiosyncrasy under high density held the answer to a decades-old question

ILLUSTRATION

Chris Lintott was reading... *On the Nature of Ultracool White Dwarfs: Not So Cool After All* by P Bergeron et al
Read it online at: https://arxiv.org/abs/2206.03174

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

On the July episode of *The Sky at Night*, **Marina Hui** takes the reigns as director for the first time, transforming the show into 'The Sky at Day'

MARINA HUI X 4, BBC, NASA GSFC/CIL/ADRIANA MANRIQUE GUTIERREZ

Within the world of television, *The Sky at Night*'s audience is particularly special. When I joined the team as the assistant producer this year, I had never worked on a series where the viewers were so passionate, engaged and grateful for the programme that was created. I quickly discovered that the show was an old friend to many and I wanted to treat the audience in kind.

As such, I aimed to fill the programme with what our audience wants – the night sky. However, therein lay a problem. Aligning the celestial calendar, our production schedule and the weather created an 'all of your eggs in one basket' scenario. Should the British weather strike, we often risked coming away from a shoot with no show at all! This is the reason why *The Sky at Night* is not always as full of the night sky as we would wish.

I realised that the weather is just as much an obstacle for our production as it is for our stargazing audience. So this month when I was given the chance to fill the shoes of the show's director, I decided to take advantage of the long summer days and make an episode filled with observations and activities that can be done in daytime, for those times when the forecast is looking a little unfriendly at night. And so, the special 'The Sky at Day' episode was born.

Passing passion on to the public

This year, as well as entertaining our audience, we've also been looking to feature them. We wanted to shine a spotlight on those who have dedicated their free time to observing and photographing the night

▲ Marina on location for a *Sky at Night* special about the daylight astronomy you can try when night-time observations are derailed by the weather

Marina Hui is the assistant producer for *The Sky at Night*

sky. For 'The Sky at Day' episode, I chose to tell the story of Simon, an amateur astronomer from Bath who has been hosting 'sidewalk solar observation' sessions. I felt it admirable that he chose to spend the sunniest weekends of the year lugging telescopes to the park so that members of the public could catch an otherworldly glimpse of our very own star.

On the day of filming, it was clear that passersby were blown away by being able to look safely at the Sun, and that they would be thinking about the Sun's spots and prominences for the rest of the day. However, it wasn't until the next day, when I climbed to the top of Bath Abbey's tower to film a sunrise, that I understood the impact of individuals like Simon. As we clambered up all 212 steps, my guide Francesca told me that they had recently hosted an outreach event with Simon and Bath Astronomical Society, and that what she had learnt from Simon had made her "obsessed with the night sky".

I feel very lucky as a filmmaker not only to be a part of one of the longest-running series in the world, but to be in a position to champion people who make it their mission to share the wonders of the Universe with others. I hope 'The Sky at Day' does an old friend justice, and that *The Sky at Night* continues to make new friends and spark new obsessions.

Looking back: The Sky at Night

21 August 1961

To commemorate the 50th episode of *The Sky at Night*, in August 1961 the show decided to broadcast something never seen on television before: live images of Saturn and its rings. Patrick Moore travelled to Brighton, where the crew mounted a television camera on a 24-inch telescope constructed by local astronomer George Hole.

▲ **Cloud cover ruined the best-laid plans for the 50th anniversary**

Any astronomer can probably guess what happened next. Just as the live broadcast was due to start, the clouds rolled in. "This, of course, is one of the hazards of astronomy," said Patrick. "The radio astronomers are luckier than us, they don't have to bother about this kind of thing." Planning for bad weather, there was a second camera on the 36-inch telescope at the Royal Observatory in Edinburgh. Halfway through the show, Patrick excitedly announced it had managed to get a view of Jupiter. Patrick and George began happily pointing out the planet's clear bands, but it was in vain. All viewers at home could see was an almost black screen.

Back in Brighton, it looked like a break in the clouds would at least allow a view of Vega. Patrick hopped around the scope, avoiding the metres-long tube as it swung into position. But as Hole got the star on the cross wires, it was gone.

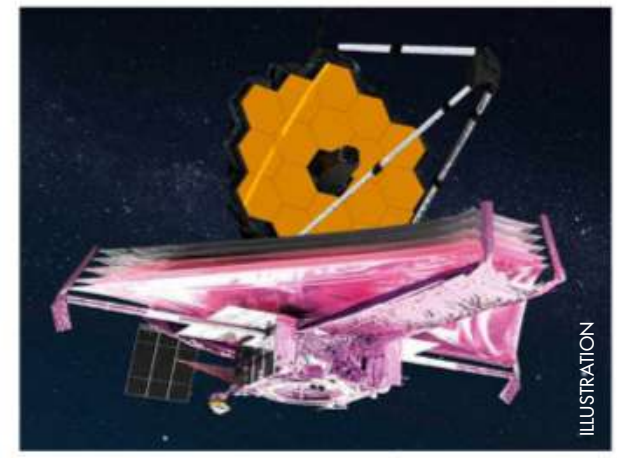
"How absolutely typical. And there's nothing we can do about it," said Patrick, letting out a good-humoured chuckle at the farce. It's hardly surprising that directors like Marina are still hesitant to trust the British weather.

You can watch clips from the episode here: **bit.ly/SaNEp50**

The James Webb Roadtrip

It's the moment we've all been waiting for: the James Webb Space Telescope finally unveiling its first observations. Chris and Maggie meet the team getting their hands on JWST data and explore the tantalising subjects it will focus on in its first year, from dying stars to exoplanets. Take a front row seat as scientists race to untangle the mysteries of our Universe.

BBC Four, **15 August**, 10pm (first repeat BBC Four, **18 August,** time tbc)
Check www.bbc.co.uk/skyatnight for more up-to-date information



▲ **Astronomers are eagerly awaiting the first images and data from the JWST**

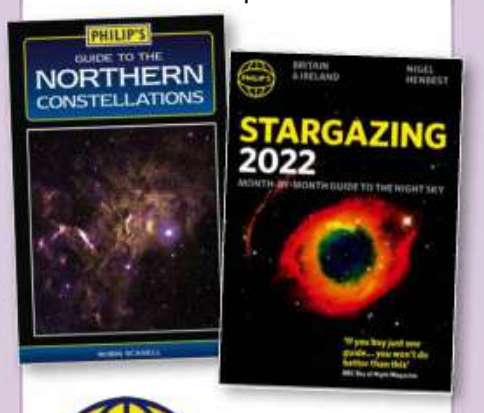
Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles



The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

New love for lunar photography

I thought you may be interested in this image I took of the Strawberry full Moon on 14 June at 11.20pm, when it was at 99.6% illumination and just 4.33° in altitude. It was created from a 30-second 4K video clip and processed in PIPP, AutoStakkert!, Topaz DeNoise and Sharpen, plus a final edit in Photoshop.

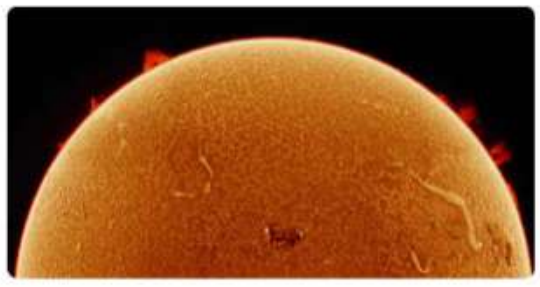
Since Covid I have moved away from my usual hobby of field mycology (the study of fungi) and wildlife photography and taken up astronomy, a subject that has always fascinated me. I have been helped considerably by members of the Mexborough and Swinton Astronomy Society who have taken me under their wing and taught me so much. I can certainly recommend people new to astronomy to search out their local society. Now I photograph the Moon almost daily when the weather allows using a tripod-mounted Olympus OM-D E-M1 MkIII camera, plus an Olympus 300mm Pro lens and x2 extender. It's a micro four-thirds camera with a crop factor of 2x vs a full-frame sensor, giving me a total focal length of 1,200mm, which is ideal for filling the image frame. I also use the same equipment plus a Baader Solar filter for solar photography.
John Leach, via email

◀ **John's fantastic shot of the Strawberry Moon**

What a wonderful capture, John. At that low an altitude, the redness of Earth's atmosphere has given the Moon a truly strawberry-like complexion, and the white craters look rather like the seeds on the outside of the fruit! ***– Ed.***

Tweet

Kevin Earp
@KevinAstrokev • Jun 21
Just messing with the last image on my phone before turning in for the night.
You can get a half Moon, but we don't often see a half Sun.
Cropped like this shows the main active regions 3030/32 so much more clearly! #astrohour @skyatnightmag #solar



Helpful hints

Thank you very much for hosting the interesting webinar with Steve Richards last evening (Telescopes Masterclass: 'Increase Your Observing Productivity with a Home Observatory', Thursday 26 May). I learned a lot and there are many ideas I want to follow up on. I appreciate Steve kindly pointing me towards the chapter in his book, *Making Every Photon Count*, about drift alignment. I own the book and I intend to try this technique out. I also want to get my head around plate solving. I feel I might get better value from my William Optics 71 and EQM35 mount if I can master them. Polar alignment has never been good enough with the lights of Dudley and Wolverhampton just up the road. I am also keen to try out some narrowband filters, which I hear can be a workaround in light-polluted skies. The three talks in the series, and especially the Q&A sessions, have been most helpful. I watched parts one and three live, but was travelling when number two was on, so will be watching Will Gaters's talk in due course via the link to the video recording.
Colin Prior, via email

Glad to hear it Colin! Our next webinar is all about the hunt for alien life with Prof. Lewis Dartnell on the evening of Thursday 14 July, and we have another three-part Masterclass series starting in September. Visit **skyatnightmagazine.com/virtual-events** for more details. ***– Ed.***

Sunset snap

I was at Mount Teide Observatory in Tenerife, Spain, back at the beginning of

Michael caught this striking shadow as the Sun set in Tenerife

June. It was sunset and I snapped this photo with my iPhone 12 Mini. I was rather pleased with how it came out and have given it no additional processing before sending it to your enjoyable magazine.
Michael Hubbard, Birmingham

What a wonderful composition, Michael, made all the better by the striking Belt of Venus off on the horizon. ***– Ed.***

Moon shot

I attended the Midlands Air Festival at Ragley Hall on 2–4 June, a three-day balloon and aircraft event. On Thursday evening there was a balloon nightglow and airborne pyrotechnics and, of course, I was keeping an eye on the position of the 10% waxing crescent Moon. With it over in the west, I was hoping to capture an aircraft near it and I struck lucky with this photo of a Grob motor-glider. Keep up the good work with the magazine.
Ian Preece, via email ▸

The glider obligingly passes the crescent Moon

ON FACEBOOK

WE ASKED: Which astronomer from history would you love to go back and meet?

Nick Williams Galileo would be my choice. I'd love to hear him describe how he felt first seeing the moons of Jupiter and Saturn's rings, which have inspired countless 'wow!' moments for observers ever since.

Steve Komarek I'd choose Carl Sagan. To be able to talk to him about life, the Universe and everything would be the most thought-provoking experience ever.

Emma Hugo I would speak with Caroline Herschel. She had such an interesting life and was an amazing astronomer in her own right.

Stuart FR I don't want to think of Patrick Moore as history, but to hear him speak of what he thought of the discoveries over just the last few years would be amazing.

Matthew Terrell William Hershel, to chat about the process behind his mirror making and the discovery of Uranus, and then his thoughts on today's modern optics.

Andy Sage I'd want to ask and see how they got or made their own telescopes in the past – no Argos back then!

Carol Miller Carl Sagan would be the one I'd like to have a chat with, and I would not want to do any serious talking, I'd just like to spend a few hours in his company. I'm sure whatever he'd talk about would be immensely interesting.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

Do you have any recommendations for a remote-controlled motorised focuser?

ROBERT STEELE

▲ **The SharpSky Pro motorised autofocuser with hand controller**

WWW.SHARPSKY.NET

The focus position of an imaging system alters with a change in temperature and usually when changing filters as, although many filters are marketed as being parfocal (meaning that they all have exactly the same effect on the light path), this is often not the case. It is, therefore, often necessary to refocus your telescope during an imaging run and this can be done automatically using a motorised autofocuser controlled with a computer.

There are two main components to an autofocuser: an electric motor and gearbox with an encoder that attaches to the focuser shaft, and the software that analyses sample star images and adjusts the focuser until the stars are sharp.

Lakeside and SharpSky Pro both produce excellent autofocusers that can be used with a wide range of telescopes and controlling software, but with the SharpSky Pro there is the added advantage of having a built-in, four-channel dew heater controller.

Steve's top tip

Why do I need a dew heater?

Dew forms on a lens when the surrounding air temperature reduces to the dew point, and the air becomes saturated with water vapour, causing the water to be lost from it in the form of liquid water droplets. Dew shields are reasonably effective at stopping dew formation. They trap a small pocket of air in front of the primary lens and reduce the rate and direction in which the air's temperature can drop, but this is often not enough. Wrapping the band of a dew heater around your telescope tube close to your optics will cause the gentle heat to travel inwards and keep the optics dew-free.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

BBC Sky at Night Magazine is published by Our Media Ltd (an Immediate Group Company) under licence from BBC Studios, which helps fund new BBC programmes.

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Audit Bureau of Circulations
23,082 (combined; Jan–Dec 2021)

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ISSN 1745-9869

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Polaris, a triple when you take a closer look

Polaris point

▸ Each time I align my 8-inch Sky-Watcher telescope and EQ5 mount with Polaris, I set up my focusing on it while the star is in the viewfinder and take a test shot with my Canon 600D DSLR camera. I noticed recently that I had captured another star close to Polaris in one of these test images. This prompted me to investigate further and I discovered that the single point of light that we see as Polaris is actually a triple star system: three stars orbiting a common centre of mass. The primary star, Polaris A, is a supergiant more than 2,000 times brighter than our Sun. The next closest companion, Polaris Ab, is a main sequence star. Polaris Ab orbits 3.2 billion km from Polaris A. Much farther away from the first two is the third companion, Polaris B. Polaris B is located approximately 385 billion km from Polaris A, and is the extra star I had captured on my shot. I think it's great that I could find out something new to me by accident: it keeps the hobby fresh and interesting.
John Consadine, Dereham, Norfolk

Instagram

tanya_captured momentimages • 26 June

First sighting of the season of noctilucent clouds, Llandudno 22/6/22 @ 00.15hrs. Noctilucent clouds are extremely rare collections of ice crystals, occasionally appearing on clear, late-summer evenings after sunset, but before it gets completely dark. #lowlightphotography #noctilucentclouds #nightskywales

Vampire slayer

The June issue's Sky Guide Challenge was to locate the planet Venus during the day, and I've just completed it! I've been wanting to do this for years and on 26 June I spotted Venus to the south of the waning crescent Moon with my binoculars at noon. Thank you for the article. I think I once heard finding Venus in the daytime sky described as vampire hunting!
Zenon Kowalewski, via email

SOCIETY IN FOCUS

Vectis Astronomical Society on the Isle of Wight (IoW) was started about 46 years ago and our observatory was opened 25 years ago. We are a registered charity and have about 50 members.

Located in a largely agricultural area in the east of the island, the observatory has clear views to the east, south and west.

We are currently updating the observatory, including the dome and its telescope, having made improvements to the teaching rooms with more networked computers and four large monitors. We have several telescopes including 18-, 12- and 10-inch Dobsonians, a 300mm Meade Schmidt-Cassegrain and a modern 4-inch refractor for astrophotography. Already some impressive photos have been taken.

We hold open evenings every Thursday and also host monthly talks. We are regularly involved in community outreach projects, including the ongoing IoW Primary School Space Camps project, science events for families and talks to community groups across the island.

▲ Vectis AS members set up telescopes outside the society's observatory

We are in the process of a final push, with the help of the local AONB, the CPRE and IoW council, to obtain International Dark Sky Association 'Dark Sky Park' status for a site in the southwest of the island. Street lighting in that area is being improved and we hope to celebrate a Dark Sky Park on the Isle of Wight later this year.
Bryn Davis, Chairman
Brian Curd, Observatory Director
▸ www.wightastronomy.org

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

VITALIYPOZDEYEV/ISTOCK/GETTY IMAGES

Live Watch the Perseids
Lighthouse Road, Swanage, Dorset, 12 and 13 August, 9pm
Join Wessex Astronomical Society at its observatory in Durlston Country Park for an evening meteor-spotting as the Perseids peak, as well as spying Saturn and the summer constellations.
wessex-astro.org.uk

Live Shadows in Space and the Stories they Tell
Methodist Church Hall, Earlsdon, Coventry, 12 August, 7:15pm
Coventry and Warwickshire Astronomical Society hosts a speaker on the second Friday of every month. This month, outreach astronomer and astrophotography expert Mary McIntyre discusses shadows: what can we learn about other worlds and their moons just by studying the shadows there?
www.covastro.org.uk

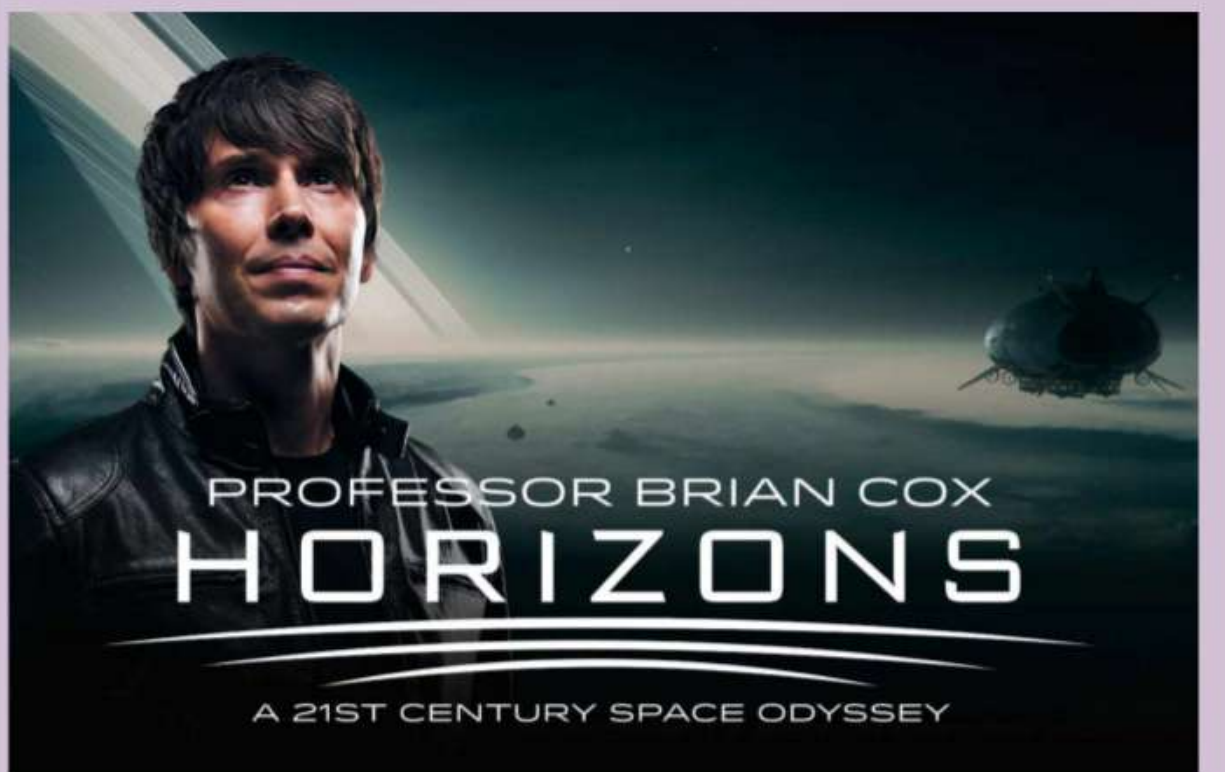
Live The Asteroid Belt
Summercourt New Memorial Hall, Cornwall, 18 August, 7:30pm
All visitors and potential new members are welcome to Kernow Astronomers' talks on the third Thursday of each month. In August, member Noel Fenwick looks at the discovery of the asteroid belt, the controversy it caused and what we now know about the region.
kernowastronomers.com

Live Dalby Forest Star Party
North Yorkshire, 18–22 August
Scarborough & Ryedale Astronomical Society's event for experienced amateur astronomers returns for three nights of stargazing and astrophotography, plus trade stalls and guest speakers, all under the super-dark conditions of a Dark Sky Discovery Site. Tickets from £10. To book, visit **www.scarborough-ryedale-as.org.uk/saras/starfest/starfest-2022**

Live Our Solar System show
Armagh Planetarium, Northern Ireland, every day, 12pm
In this brand-new interactive dome show, your planetarium guide will take you for an up-close view of the planets and to safely gaze at our star, the Sun. Running time 35 minutes. Suitable for all ages. Adults £9, children £6.
www.armagh.space

Live Solar observing
Dunwich Beach, Suffolk, 28 August, 11am
Unless clouds stop play, join DASH Astro for a safe, guided three-hour solar observing session, meeting at the National Trust car park at Dunwich Beach.
www.dash-astro.co.uk/events

PICK OF THE MONTH



▲ Professor Brian Cox brings his *Horizons* show to UK venues including the Royal Opera House

LIVE Horizons: A 21st-Century Space Odyssey
Professor Brian Cox tours the UK with his epic big-visuals show, 1 August –2 October

An awe-inspiring cinematic exploration of the Universe, combined with physicist Brian Cox's trademark impassioned style and in-depth knowledge promises to make this an unmissable show. *Horizons* visits alien worlds, supermassive black holes and travels back to the time before the Big Bang, tackling all the big questions along the way. This home leg of his global arena tour sees events at the Royal Opera House and a one-off at the O2, followed by stops all across the UK. Cox is joined by his co-host on *The Infinite Monkey Cage*, award-winning comedian Robin Ince. Tickets from £10.
briancoxlive.co.uk

mpb.com

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FIELD OF VIEW

Drive me to the Moon

Artist **Oliver Jeffers** on creating the Our Place In Space sculpture trail

The trail winds its way through Cambridge this month

Oliver Jeffers is an Australian-born, Northern Irish visual artist who lives in New York. A sculptor, illustrator and writer acclaimed for his children's books, he has exhibited at the National Portrait Gallery and received an MBE in the 2022 New Year's Honours List for services to art

Assuming the average speed that people drive is 60km/h, how long would it take to get to the Moon? The answer is about a year, if you took breaks. To get to Mars it would be 400 years, to Saturn 2,500 years; to get to Pluto it would take nearly 10,000 years.

Scale and perspective are things I've been interested in with my work and many of my projects involve the night sky. I like looking at the great unknowns of the sea and the sky, and looking at Earth from a distance. After reading about just how hard it is to portray the size of the Solar System accurately, I wondered if there would be a way to make a scale model. The result, Our Place In Space, is a sculpture trail that ran in Derry-Londonderry and Belfast in April to July, and comes to Cambridge in July and August.

There were two things that had to fall into place for this to happen. One occurred while I was in the USA, when the path of totality from a solar eclipse went across the country in 2018. We drove to Tennessee to be in the path and accidentally ended up in the best spot, on a bridge across a dam. We met Dolly Parton the same day, but even she couldn't eclipse the eclipse.

It was two o'clock in the afternoon in the middle of summer and the light started getting weird. It was like the sodium glow of a car park at night, then all of a sudden there it went, it turned from day to night, like someone flicked the switch. And you could actually see stars. When it got to totality it was like a black hole had appeared in the sky, and that's when I realised, I'm looking at two different objects in a line.

You don't need numbers to understand spatial awareness physically, so I asked myself, how can I show this in some way? I thought of a scale model of the Solar System where you'd be able to line it up with your own eye. But then if Earth was the size of a ping-pong ball in the scale model and Mars was a marble 200m away, you wouldn't be able to see them.

Then the last piece of the puzzle came when I was in Las Vegas for the American Librarian Association – with 10,000 librarians. There, everything is fighting for your attention, with neon lights and arrows, and I thought, "That's how we do it!" We build modern art sculptures, arches which will hold the planets that are accurate to scale, each with a giant illuminated arrow so your brain can work out roughly where the next one is and you get that sense of spatial scale.

I wanted to use the perspective of Earth's place in our Solar System as a way to look at how we fight over the only space in the Universe that's habitable to human life. When you get to Pluto, which is two kilometres past Uranus, it's like the size of a match head, and the next stop is Alpha Centauri, which at the trail's scale would be 160,000km away. At each point you're encouraged to think back and look back at Earth. The aim is to get people to think about how long it would take in reality to get to that point and what was happening on Earth that long ago.

Many of these events in history tie back to some territorial dispute. We have quite literally and figuratively been fighting each other over space, as we hurtle through space, since civilisation began. My hope for Our Place In Space is that it gives visitors a widefield view of how unnecessary all that is.

For more about the trail, visit the website at ourplaceinspace.earth

OLIVER JEFFERS

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BBC Sky at Night MAGAZINE

Showstopper M27, the Dumbbell Nebula, one of the beautiful targets for your planetary nebulae hunt

A parade of PLANETARY NEBULAE

Stuart Atkinson seeks out six of the loveliest examples of these deep-sky objects for you to track down in the late-summer skies

One of the most fascinating facts I ever learned about astronomy is that stars don't last forever: like us, they are born, live a life and eventually die. Okay, so those lives are rather longer than ours, but every single star in the sky is on borrowed time.

Thanks to science fiction, a common misconception is that all stars die in cataclysmic explosions, like the Death Star. The largest do, becoming supernovae that can briefly outshine a whole galaxy, while the smallest ones just shrink and fade away, like forgotten pop stars. In between, the quieter, less attention-seeking stars the size of our own Sun – that is, with diameters of a million kilometres or so – die like celestial souffles, swelling up and then shrinking again; but not before they pop, puff off their outer layers like colourful smoke rings and surround themselves with beautiful shells of gas and dust. Because through the eyepiece these shells have a resemblance to planets, they are known as 'planetary nebulae'.

Planetary nebulae are important scientifically because they allow us to study the evolutionary processes of stars similar to our own Sun, and see into its future. By studying them at different wavelengths, we can explore the amount and composition of the dust and gas inside their shells, allowing us to understand better what stars are made of. It's even possible to watch the material inside a planetary nebula's shells expanding, by taking multiple images over long periods of time and comparing them. We won't be around to see what happens to the Sun as it nears the end of its life, but studying planetary nebulae allows us to jump in a TARDIS and travel into the future to do just that.

Keep it dark

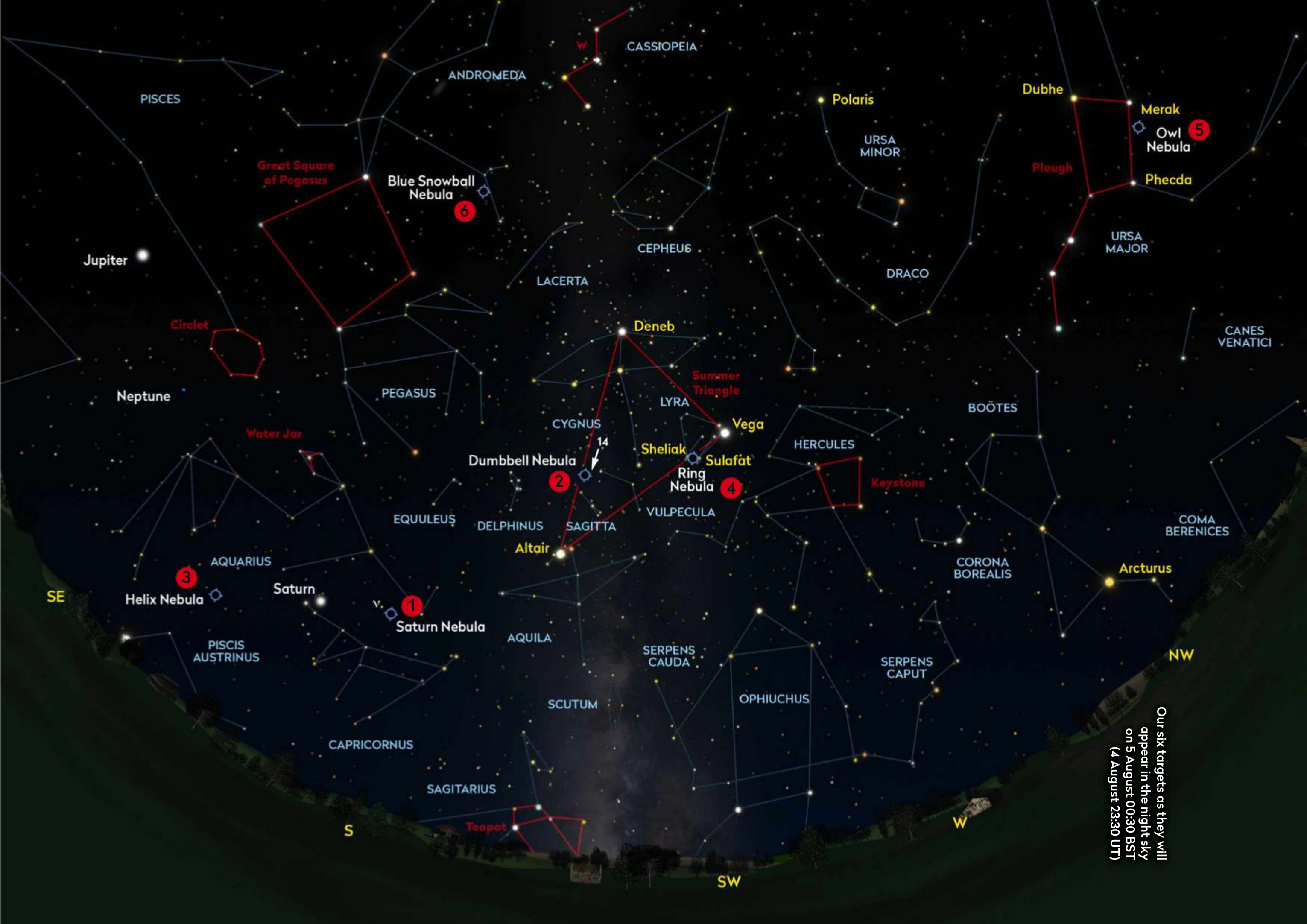
These fascinating objects are also simply beautiful to look at, and now is a great time to observe them because a wide variety are scattered across the sky, many in constellations around the frothy borders of the Milky Way, which is famously best seen at this time of year.

The trick is to wait until the sky is as dark as possible – no Moon, no light pollution – and then, after finding the nebula in a widefield eyepiece, use your favourite high-magnification eyepiece to really zoom in. You'll see the striking contrast between the nebula and the sky around it, unusual shapes, ghostly smoke rings and delicate puffballs. If the seeing is very good and your equipment is behaving, you might even see the star at the centre, like a tiny pollen grain surrounded by the shells of glowing gas and dust.

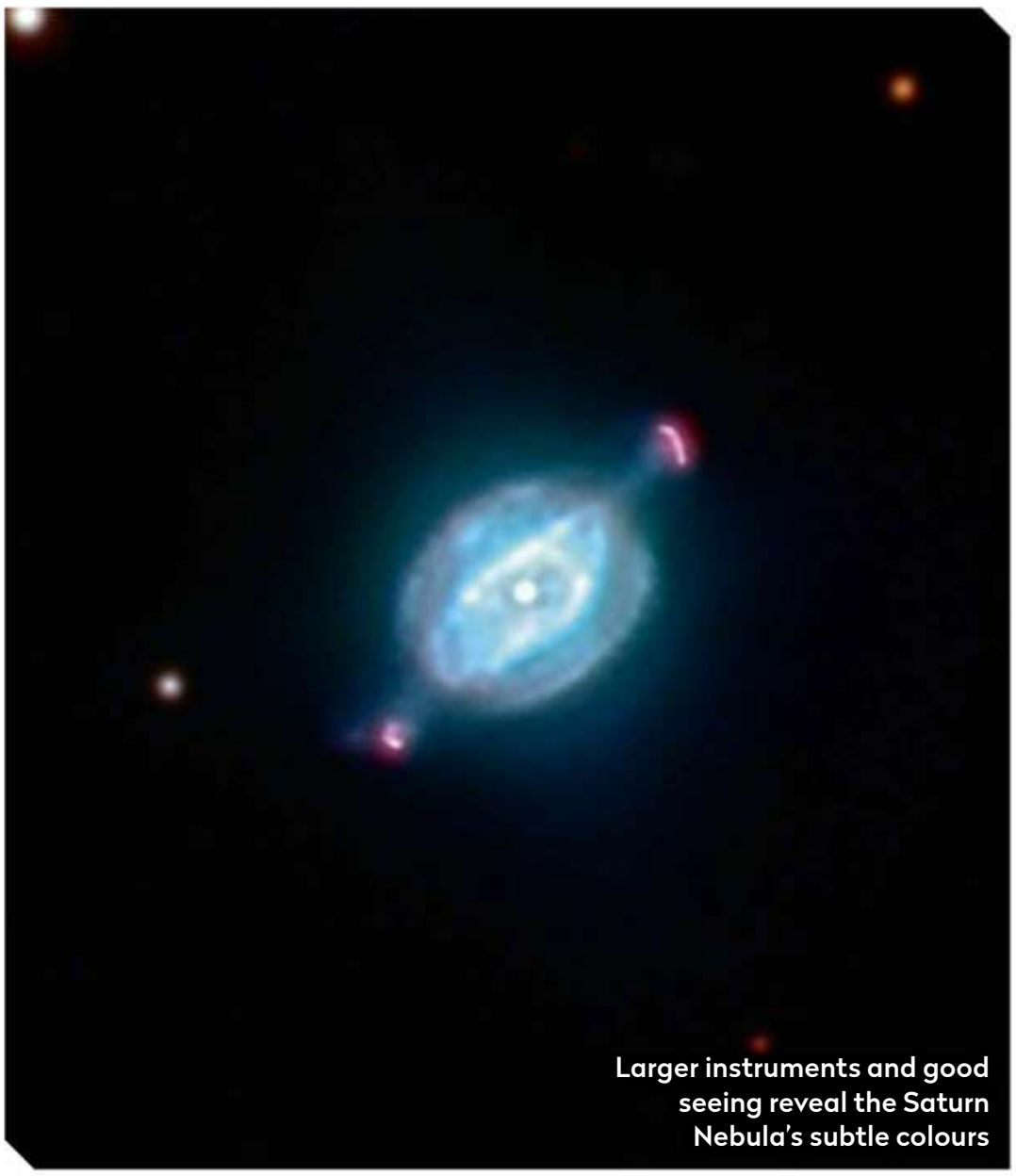
Although the sky never gets truly dark during the next couple of months, it still gets dark enough to find the planetary nebulae on our list. So whether you own a Dobsonian 'ship's cannon', a small refractor or even just a pair of binoculars, there will be something here for you to see. ▸

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

CHRISTOPH KALTSEIS/CCDGUIDE.COM



Our six targets as they will appear in the night sky on 5 August 00:30 BST (4 August 23:30 UT)



Larger instruments and good seeing reveal the Saturn Nebula's subtle colours

1. The Saturn Nebula

Catalogue number: NGC 7009
Constellation: Aquarius
Magnitude: +7.8
Equipment: 6-inch scope

There are no prizes for guessing how this nebula earned its nickname. With its bright core and small 'wings' on either side, it really does resemble a smoky, slightly blurry Saturn through the eyepiece of a telescope under high magnification. This was how it looked to the Earl of Rosse who gave it the name after observing it with his giant Leviathan of Parsonstown telescope around 1840, and possibly to William Herschel when he first discovered it in 1782.

The Saturn Nebula lies around 2,900 lightyears away from Earth and you should be able to find it fairly easily, just under a degree and a half west of mag. +4.5 star Nu (ν) Aquarii. You will need really high magnification, good seeing and a dark sky to pick up its faint blue-white colour. Coincidentally, during August the real planet Saturn will be shining fairly close by, below and to the east of the Saturn Nebula, so you should be able to directly compare the two through your telescope.

CHART BY PETE LAWRENCE, DANIEL VERSCHATSE/CCDGUIDE.COM, CHRISTOPH KALTSEIS/CCDGUIDE.COM

2. The Dumbbell Nebula

Catalogue number: M27
Constellation: Vulpecula
Magnitude: +7.1
Equipment: 3-inch scope

A ghostly disc with a bite taken out of each side, the Dumbbell Nebula is one of the most recognised planetary nebulae in the sky. It is large and bright enough to see with a small telescope and even looking through binoculars – if you know exactly where to look. It is easy to lose sight of it amid all the peppercorn stars of the Milky Way, close to the celestial crowds of the Cygnus Star Cloud.

At low powers the Dumbbell Nebula is more oval than dumbbell-shaped, looking like a tiny, misty rugby ball. You will need to crank the magnification up to observe the twin lobes, or fans, that give it its name. That will also help your eye to detect the subtle green hue of the nebula, but only if your eyesight is dark-adapted under a dark sky. You will find M27 near to the sharp tip of the starry arrow constellation, Sagitta, and just 23 arcminutes beneath the mag. +5.7 star 14 Vulpeculae. ▸

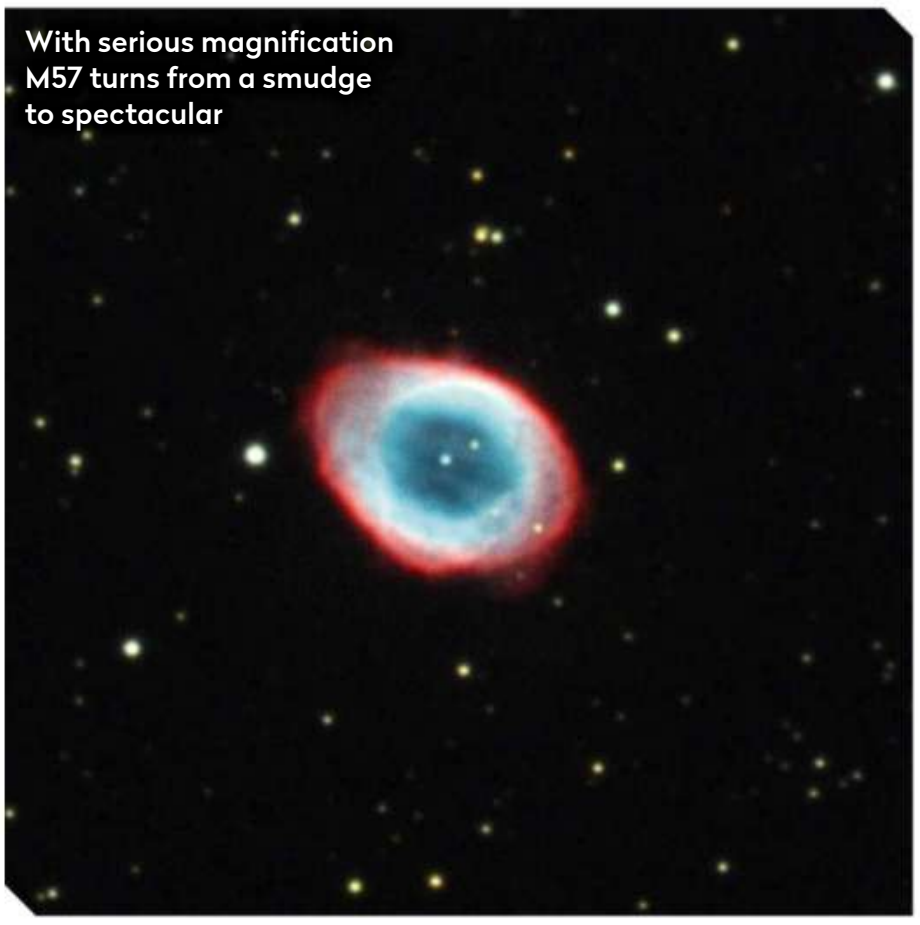
You can spot this big, bright favourite even with a pair of binoculars

3. The Helix Nebula

Catalogue number: NGC 7293
Constellation: Aquarius
Magnitude: +7.6
Equipment: 6-inch scope

The Helix Nebula is perhaps the closest planetary nebula to our Solar System, around 650 lightyears away, and is approximately 2.5 lightyears across. It is a much-loved object among deep-sky astrophotographers because of its complicated structure and size, but visual observers find it rather challenging and often frustrating. You can seek it out about a third of the way between Upsilon (υ) Aquarii and 47 Aquarii. Visually it is a large object, around half the size of the full Moon, but being so big means its faint light is spread over a wide area, giving it a low surface brightness that presents a challenge for small scopes and binoculars. Larger scopes fitted with low-power eyepieces show it as a pale, hazy disc. Only under really good conditions will a telescope be able to show any of its multiple pale arcs and crescents of smoky light.

The giant eye of the Helix Nebula is – ironically – tricky to see due to its low surface brightness



With serious magnification M57 turns from a smudge to spectacular

4. The Ring Nebula

Catalogue number: M57
Constellation: Lyra
Magnitude: +8.8
Equipment: 6-inch scope

M57 is arguably the most famous planetary nebula in the sky because it actually looks like the thing it's named after, a ring – although only through a telescope. Through binoculars you can just make out M57 as a blue-green dot looking almost like an out-of-focus star, halfway between the 3rd-magnitude stars Sulafat (Gamma (γ) Lyrae) and Sheliak (Beta (β) Lyrae), down at the base of Lyra, the Lyre.

A small telescope reveals tantalising hints of its ring structure (using averted vision helps), but point a medium to large telescope at it and the ring will jump out at you, as will its slightly oval shape. If you really pump up the magnification you'll be able to see the 12th-magnitude parent star in the centre of the ring. Be aware that while M57 has a distinctive red colour on long exposure photos, your eye will only see it as a misty grey-green.

GERALD RHEMANN/CCDGUIDE.COM, CHRISTOPH KALTSEIS/CCDGUIDE.COM, JOHANNES SCHEDLER/CCDGUIDE.COM X 2

Use averted vision to catch a glimpse of the Owl's central dying star

5. The Owl Nebula

Catalogue number: M97
Constellation: Ursa Major
Magnitude: +9.8
Equipment: 8-inch scope

Despite its low brightness, M97 is a popular target for deep-sky observers and photographers alike. It's one of the easiest planetary nebulae to find because it lies just below the universally familiar Big Dipper or Plough asterism, on the right side of the bottom of its bowl, just over 2° – or four Moon widths – away from the lower of the Big Dipper's pointer stars, Merak (Beta (β) Ursae Majoris).

It's also a favourite because of its striking appearance through a telescope. While with smaller scopes and binoculars you will see a dimly glowing disc, a large instrument and high magnification will reveal more of its structure: a round, pale, smoky blue-green ball with two dark areas inside it that really do give it the appearance of an owl's face, with two blinking eyes. At 16th magnitude, the central star is very faint but might pop in and out of view if you use averted vision. M97 is estimated to be around 2,030 lightyears away and two lightyears wide.

6. The Blue Snowball Nebula

Catalogue number: NGC 7662
Constellation: Andromeda
Magnitude: +8.3
Equipment: 6-inch scope

A less well-known target to seek out this summer is the Blue Snowball Nebula, although NGC 7662 is close enough to the north celestial pole that it is visible from the UK on almost every night of the year. You'll find it in a relatively barren area of sky between the Great Square of Pegasus and the W of Cassiopeia. As its name suggests, it is a round, fuzzy object that shines with a pale blue colour that is hinted at in small telescopes but more obvious in larger instruments.

Under high magnification, on a dark night and with good seeing, you'll be able to spot subtle variations of shade and colour, and you may even be lucky enough to catch sight of its very faint central star. Recent studies suggest it lies 5,600 lightyears away and has a diameter of just under a lightyear. Look for it between the stars Iota (ι) Andromedae and Omicron (ο) Andromedae.

Look for the bright Blue Snowball's distinctive blue tinge and elongated shape

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BBC Sky at Night MAGAZINE

Exoplanets – those that orbit stars other than our Sun – are a rich area of current research

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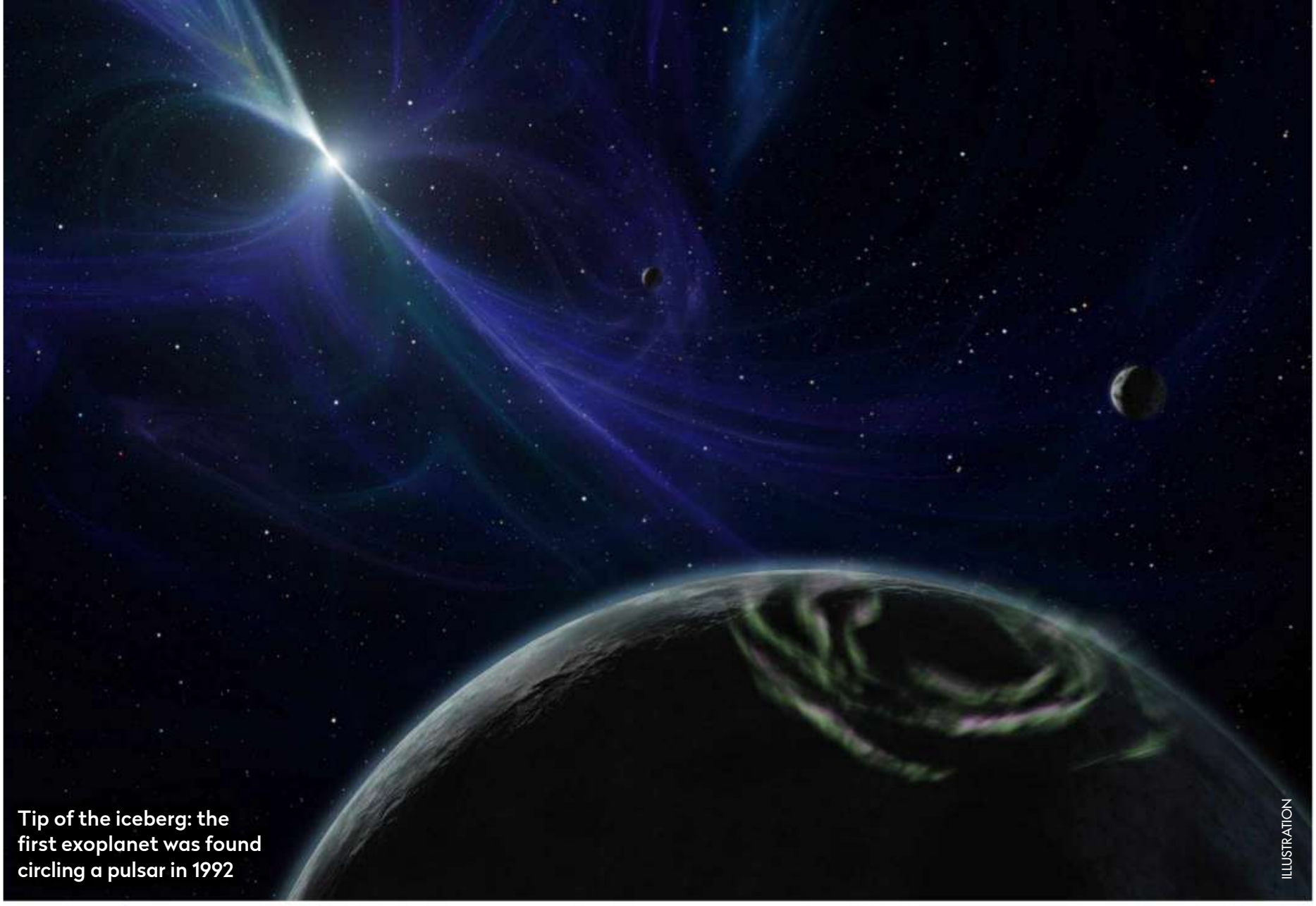
From possible planets to STRANGE NEW WORLDS

With 5,000 exoplanets now confirmed and another 5,000 waiting to follow suit, **Ezzy Pearson** takes a look at how a deluge of tantalising data is revealing intriguing new worlds every day

Back in 1992, humanity received its first definitive answer to a question it had been asking for centuries: are there other worlds beyond our Solar System? The answer came in the form of Poltergeist and Phobetor, the first potential planets to have their existence confirmed and become fully fledged exoplanets.

Over the following three decades, dozens of surveys and observation campaigns have tracked down ever more exoplanets in the Milky Way, and on 21 March 2022 the NASA Exoplanet Archive announced it had passed the threshold of 5,000 validated exoplanets.

But while it took 30 years to reach this number, doubling it will take considerably less time. In the same month as the archive's announcement, astronomers working on NASA's Transiting Exoplanet Survey Satellite (TESS) revealed they had ▸



Tip of the iceberg: the first exoplanet was found circling a pulsar in 1992

ILLUSTRATION

▸ obtained another 5,000 exoplanet candidates, which were awaiting confirmation, and there were even more to come.

It's a huge number to keep track of. Back in the early days when there were only a few known exoplanets, astronomers would each have their own spreadsheets listing them. But as the dozens grew to hundreds and then thousands, it became apparent a dedicated system was needed, leading NASA to create the Exoplanet Archive.

"NASA keeps track of all the planets we've found outside our Solar System and anything we know about them," says Jessie Christiansen, the lead scientist for NASA's Exoplanet Archive at Caltech, who updates the archive. "It's a big database of everything that we know about exoplanets and the stars they orbit."

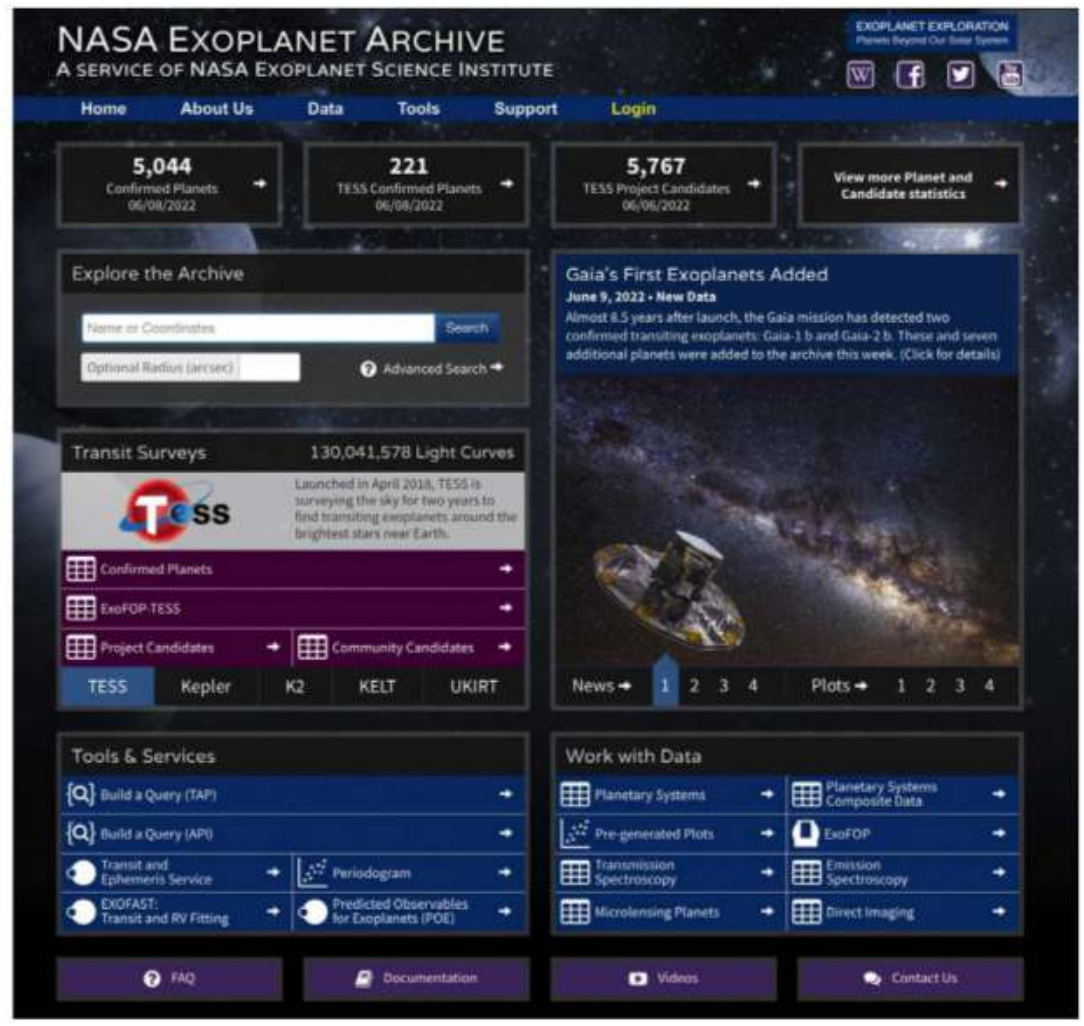
I would find 5,000 worlds...

With all this information in one place, astronomers can look up any exoplanet they like and discover all its known properties, from size to mass, what kind of star it orbits or if it has any siblings. Or they can sift through the data to find only the exoplanets that match their criteria, such as those with a specific orbit that fits their observing run. Alternatively, they can extract the mass measurements to look at the bulk properties of the entire population of exoplanets discovered so far. In fact, it was doing this that turned up one of the biggest surprises about planetary systems beyond our own.

"One of the most common sizes of planet is actually in between Earth and Neptune," says Christiansen. "We call them super-Earths, or mini-Neptunes depending on exactly where they lie."

It's worth bearing in mind when looking at the archive's planets en masse that they aren't an

"Astronomers working on TESS revealed they had obtained another 5,000 exoplanet candidates – and there were even more to come"

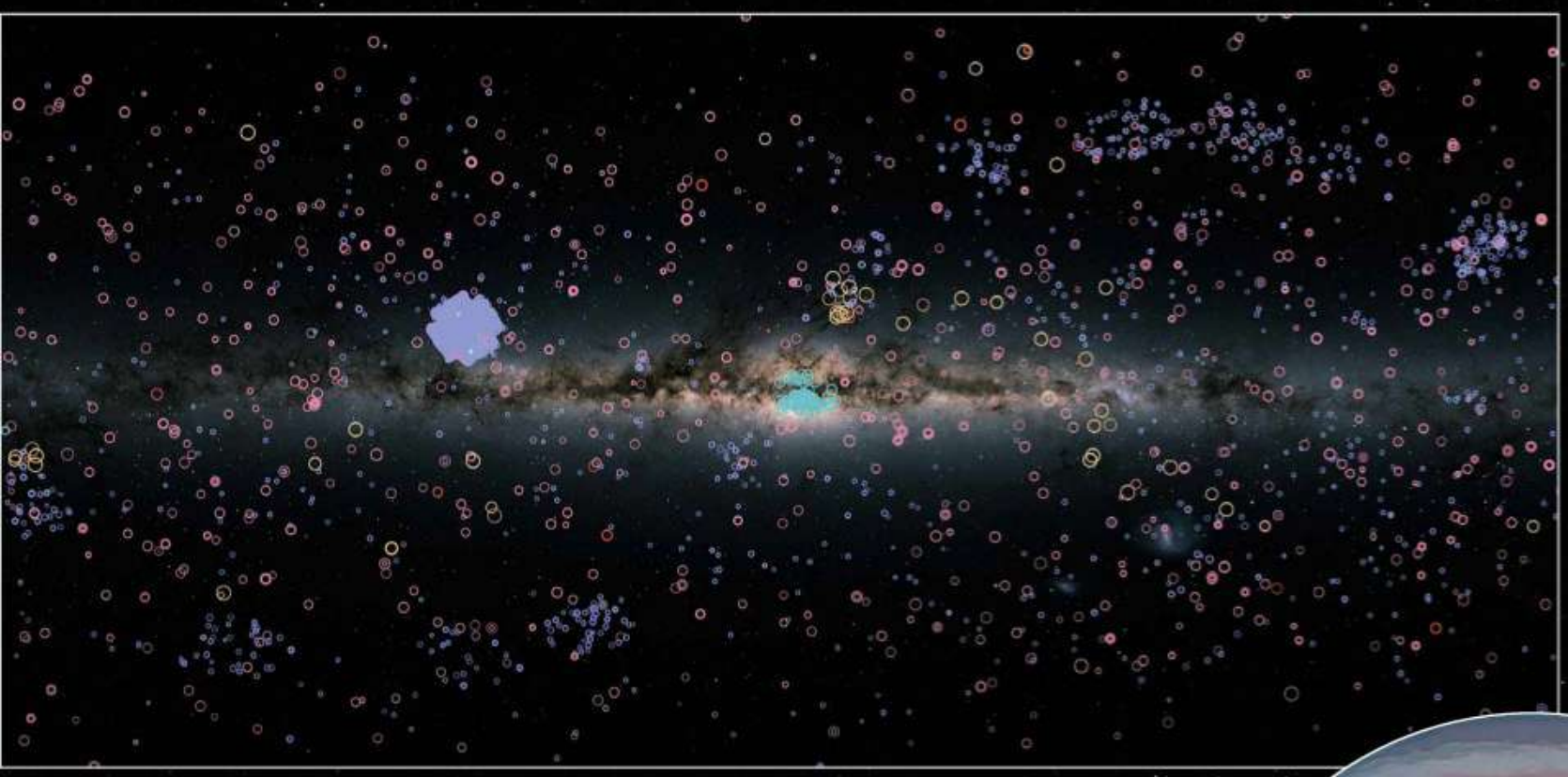


▲ NASA's Exoplanet Archive (exoplanetarchive.ipac.caltech.edu) contained 221 TESS-confirmed planets and 5,767 candidates, at the time of writing

NASA/JPL-CALTECH, NASA, NASA/JPL-CALTECH/SYSTEM SOUNDS (M. RUSSO AND A. SANTAGUIDA), NASA/JPL-CALTECH

The planets of the archive

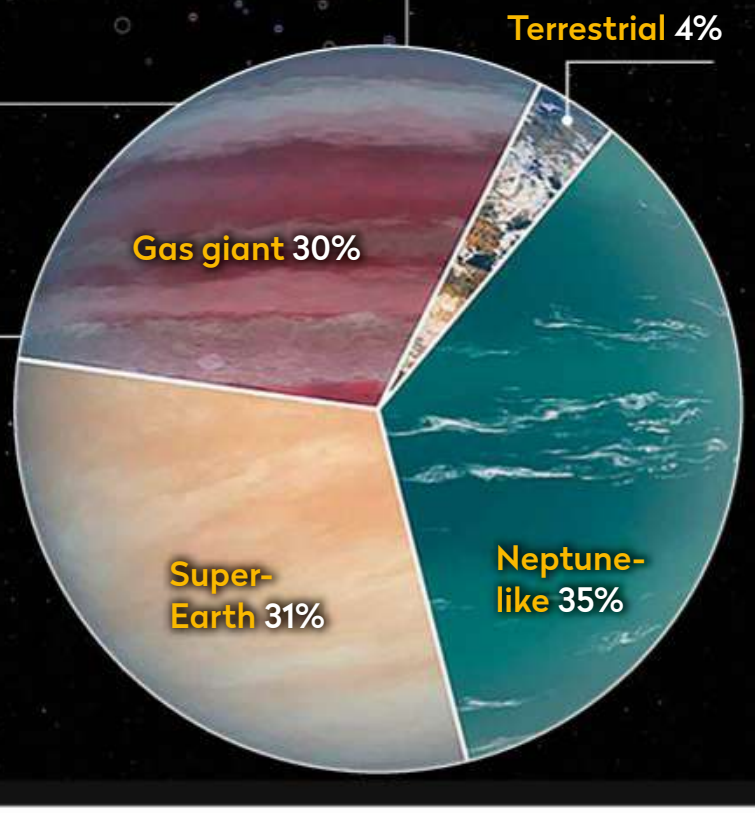
The new worlds of the Exoplanet Archive are located all over the Milky Way. Here's where they have been found and what types of planet they are



METHOD USED

- Radial velocity 913
- Transit 3,846
- Imaging 58
- Microlensing 129
- Timing variations 48
- Orbital brightness modulation 9
- Astrometry 1
- Disc kinematics 1

▲ Various surveys and detection methods have found exoplanets across the night sky, but some areas have been examined more deeply than others, thus finding more planets. This is particularly obvious in the dense purple patch just left of the galactic centre, which marks the area covered by Kepler.



Gas giant: Planets similar to Jupiter or Saturn, though some are many times larger. Their size means they are some of the easiest to detect.

Super-Earth: Ranging in size from Earth to Neptune, these planets could be rocky like Earth, or shrouded in puffy atmospheres. Despite being numerous elsewhere, they are absent from our own Solar System.

Neptune-like: These worlds are similar to the ice giants Neptune and Uranus. Though there have been some examples of 'warm Neptunes' found in orbits closer to their star than the ice giants are to the Sun, they are rarer.

Terrestrial: Rocky planets similar to our own home planet. Among the smallest planets known, current methods struggle to detect these worlds.

accurate reflection of the overall population of exoplanets in our Galaxy, but rather of the ones that are easiest for astronomers to find.

"The missions that have been prolific so far are transit missions," says Christiansen, referring to the planetary detection method of looking for the brief dip in a star's brightness as a planet passes in front of it. "The vast majority of those 5,000 planets are closer to their star than Earth is to the Sun, because we haven't done a complete job of exploring for all planets, such as we'd find in our Solar System."

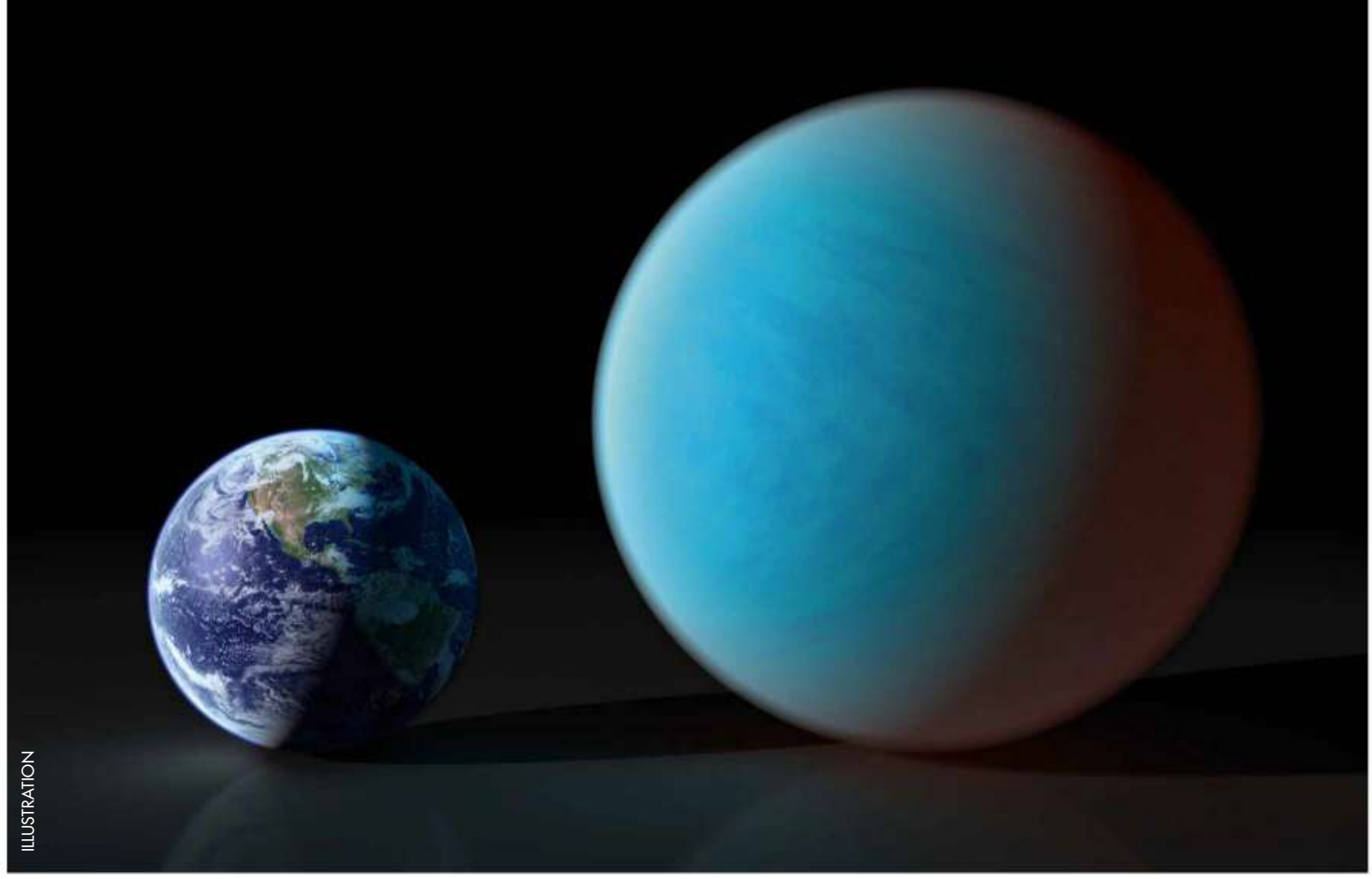
As larger planets create bigger dips and those with shorter orbits transit more frequently, around one third of the planets in the archive are gas giants very close to their star, known as 'hot Jupiters'.

"Even though these were the first planets to be found, we actually don't think they're very common. They're just by far the easiest to find because they're big and transit so often," says Christiansen.

Whether super-Earth, mini Neptune or hot Jupiter, the most prolific planet finder of the last 30 years has been the Kepler Space Telescope. It observed a small section of the star-rich Milky Way for almost 10 years and now has over 2,700 confirmed exoplanets in the archive.

And I would find 5,000 more

But what Kepler took a decade to achieve, its successor, TESS, has done in just two years, with 5,000 potential exoplanets already detected and awaiting confirmation. The mission has already completed its primary science phase, spending one year scanning the southern sky and then another scanning the northern sky. Now in its third year, the spacecraft is scanning along the ecliptic. The big ▸



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◄ **Earth to scale with 55 Cancri e, the first super-Earth found around a main sequence star, where temperatures reach 2,700°C and a year lasts less than 18 hours**

► difference between exoplanets in the archive and TESS's 'planets' is that the latter are still only possible planets. So far, only 200 of TESS's candidates have been verified.

"It takes a lot of work to turn a candidate into a confirmed planet," says Christiansen. "You have to get high-resolution imaging to make sure it's a single star. You need high-resolution spectra to make sure you've understood the properties of the star. There's a lot of ways it can fail on the way to being a confirmed planet."

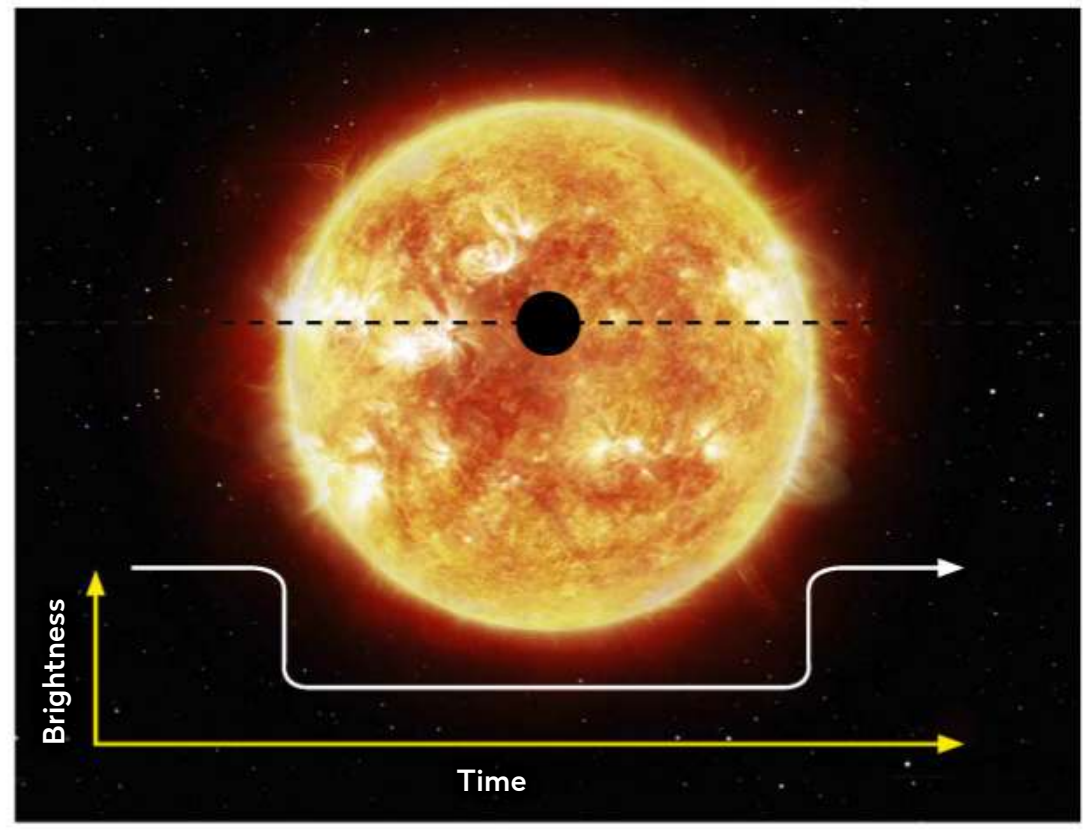
Drawing on their experience with Kepler, the TESS team have put a conservative estimate on their catalogue that around 80 per cent of the candidates will prove to be real and earn a place in the Exoplanet Archive. However, getting these planets their verified place might be difficult, because while Kepler had a portion of its funding dedicated to follow-up, the same is not true for TESS.

"There's a much smaller paid component for TESS follow-up," says Christiansen. "But there is a much wider community participation because the data is public. We do have an observing programme steering committee, however, with the goal of ensuring we don't have five teams all working on the same star without knowing it. People are volunteering because the TESS targets are so interesting."

TESS of the habitables

Given the interest in these new exoplanets, you might be surprised to hear that TESS's planets are in many ways similar to those already in the archive. The survey covers each section of sky for just 21 days, during which time a planet needs to transit two or three times to be flagged as a candidate. While there is some overlap between sections, meaning some parts of the sky were observed for as long as six months, most of the planets had orbits of just a few days – just like with Kepler. Instead, what makes the next 5,000 planets so interesting are the stars they are orbiting.

"Kepler did faint stars in one little patch of sky," says Christiansen. "TESS is looking at bright stars around the whole sky." Indeed, with so many



▲ **The transit method of detection picks up the dip in brightness of a star as a planet passes between it and the observer**

exoplanets to draw on, researchers are increasingly moving from finding them to learning more about them. One area of keen interest is their atmospheres. When a planet transits, some of the starlight passes through the atmosphere. Just like on our own planet, the gases in the air interact with this light – absorbing some wavelengths, emitting others – and leave behind a signature, which remains encoded in the light as it travels across lightyears and arrives at Earth. When astronomers observe it, they can decode the signature from the starlight and work out what gases might exist in that planet's atmosphere.

The brighter the star, the easier this pattern is to see, making TESS's planets the perfect targets. But even then, a powerful telescope is still needed to pick out the tiny fluctuations caused by the planet. Fortunately, the recently launched James Webb Space Telescope fits the bill perfectly.

"For the first time in human history we will be able to collect enough light from a planet as small as Earth to read the composition of its air," says Lisa Kaltenegger, director of the Carl Sagan Institute and a TESS science team member. The stars that TESS has been finding have all been bright when viewed

NASA/JPL-CALTECH/R. HURT (SSC), ESA, ESO/M. KORNMESSER, GSFC/SVS, ESO

ILLUSTRATION

Three Earth- and Venus-like planets were discovered orbiting an ultracool dwarf star just 40 lightyears away by the TRAPPIST telescope

from Earth, but in many cases this is because they are close by, not because they are objectively bright.

"Most stars in our neighbourhood are actually small, red stars. Eighty per cent of them are smaller than our yellow Sun, actually," says Kaltenegger. "They are not so hot and not so bright."

As these stars are much cooler than our Sun, so too are the planets around them. In fact, those planets which orbit their star once every 10 days to a month – a category many of TESS's planetary candidates fall into – would be right in the middle of the star's habitable zone.

"This is where it's not too hot and not too cold, so you could have liquid water on the surface of the planet," says Kaltenegger. "That's one of the key ingredients for life, but also for us to find life on a planet that is far away." Water will be one of the key chemicals that the JWST will be looking for, but it will be capable of tracking down many more, including carbon dioxide. Here on Earth, the gas is created as a waste product by many forms of life, that then release it out into the atmosphere. If alien life was doing the same on its own planet, JWST would be able to detect it.

"We have the first instruments that could actually find signs of life on other worlds," says Kaltenegger. "It's going to be super hard to do, but it's possible. If we get really lucky."

It could just be that the planet which holds the first signs of extrasolar life might have already been discovered and is sitting in the archive, waiting to reveal itself.

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is available through History Press

What's next?

A flood of exoplanet detections is expected over the next decade

One thing's for sure: the number of known exoplanets is about to dramatically increase. Not only is TESS continuing to scan the skies for a third year – and potentially more beyond that – there are several other missions gearing up to add to the roster as well.

The European Space Agency's Gaia telescope has been monitoring the positions of over a billion stars for several years. Though not its primary goal, these observations could detect upwards of 20,000 planets from the slight wobble caused by their gravitational pull on their star.

The Nancy Grace Roman Space Telescope is currently being developed by NASA for a launch in 2027. This will use a technique known as microlensing, whereby the telescope looks for starlight being bent by the gravity of unseen masses – including by exoplanets. Not only will this uncover planets far smaller and further out than the transit method can, it's expected to unearth some 100,000 of them. "During the pandemic we overhauled the archive to accommodate the fact that we'd just got too big for our old tables and our old processes," says Christiansen. "We're looking ahead and realised we need to update our methods to handle the load over the next five years."

ILLUSTRATION

▲ The Nancy Grace Roman Space Telescope will survey exoplanets in infrared light

Tiangong
the Chinese Space Station

China is taking its place among the heavens as it puts the finishing touches to its first long-term space station

The China National Space Agency (CNSA) has become a major space player over the last decade. This year, the nation hopes to take its next leap towards the heavens and complete its first long-term space station, Tiangong, which translates as 'heavenly place'.

A crew of three 'taikonauts' are already on board the Tianhe core module, which launched last year. They will oversee the installation of the final two science modules, the first of which, Wentian, is due to launch on 23 July. The goal of the station is to give CNSA the know-how to send crews to live in space, and Tiangong is a key component of China's ambitions to send humans to the Moon and on to Mars.

China has constructed its own station as US law prohibits NASA from working with China, effectively barring them from the International Space Station. However, the nation is keen to collaborate with other international partners and has already run joint training exercises with ESA. Indeed, China's aim is that Tiangong will act as a new hub of international cooperation in space once the ISS is decommissioned in 2031.

ADRIAN MANN/STOCKTREK IMAGES/ISTOCK/GETTY IMAGES X 2

Shenzhou – 'Divine vessel'

The Shenzhou transport vehicle is the main vehicle used by China for its human spaceflight programme. It borrows heavily from the Russian Soyuz capsule, though is slightly larger and can carry up to three passengers at a time.

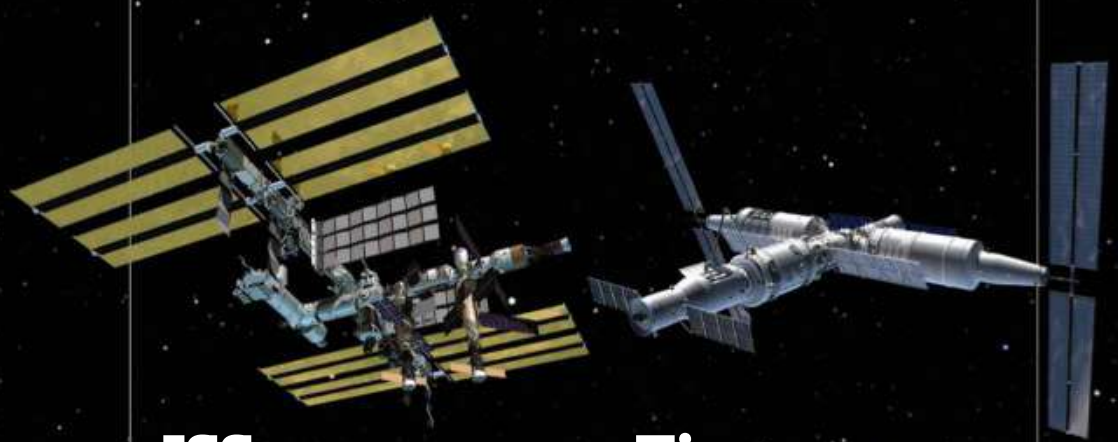
Mengtian – 'Heavenly dream'

Launch: October 2022
Mengtian will form the final instalment of the space station. As well as its interior serving as a laboratory, it has a cargo airlock where replacement parts or external experiments can be delivered outside the station. From here taikonauts and robotic arms can place them on the station's hull.

Solar panels

The station is powered by solar arrays. The solar panels on Wentian and Mengtian are about 30m long and will provide most of the station's power. A set of smaller arrays on Tianhe measures 18m long.

ISS vs Tiangong



ISS
Living space: 916m³
Length: 108m
Normal occupancy: 6
Orbit height: 408km

Tiangong
Living space: 110m³
Length: 20m
Normal occupancy: 3
Orbit height: 389km

Wentian – 'Heavenly quest'

Launch: 23 July 2022
A laboratory module where scientific experiments, both from China and international partners, can be conducted. It will contain an airlock to allow taikonauts outside to conduct spacewalks. The hull has several stations where external experiments can be set up. The module also contains back-up avionics and propulsion.

Tianhe – 'Harmony of the heavens'

Launch: 29 April 2021
The core module and central node of Tiangong, this provides the essential functions of the space station – life support, navigation, propulsion – as well as the living quarters for up to three crew members.

Tianzhou – 'Heavenly ship'

An automated freight vehicle which can transport large payloads up to a mass of 6,500kg to the station. Like almost all the components of the station, they are launched on Long March 7 rockets.

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SCAN ME

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

AUGUST 2022

SATURN AT OPPOSITION

Saturn reaches opposition mid-month and its famous rings appear to increase in brightness

VESTA'D INTEREST

Asteroid 4 Vesta joins in the opposition movement

REINER GAMMA

What formed this distinctive lunar feature?

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Mars and Uranus in conjunction
- The Dumbbell Nebula
- Reveal a dynamic Moon by recording its moving shadows

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

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For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

AUGUST HIGHLIGHTS

Your guide to the night sky this month

All month

August represents the last chance to see brightening Comet C/2017 K2 PanSTARRS from the UK. The comet starts the month in southern Ophiuchus, ending August near the claws of Scorpius and continuing to brighten all the while before reaching perihelion in December.

Monday 1

The first opportunity to take our Deep-Sky Tour on page 56 occurs in the first week of August before the bright Moon interferes. The second opportunity occurs starting on 20 August through to the end of the month. This month we're looking at objects around Sagitta.

Tuesday 2

The mag. +5.8 planet Uranus appears just 1.3° north of mag. +0.2 Mars this morning. The pair are located about 20° above the eastern horizon at 02:30 BST (01:30 UT). Binoculars may give a view of dim Uranus.

Wednesday 3

Magnitude –0.3 Mercury is roughly 1° from mag. +1.3 Regulus on 3 and 4 August, making it a possible telescope target for daytime viewing. If you try, however, take care as the Sun will be just 18° to the west.

Sunday 7

With just a week to go before Saturn reaches opposition, this is the time to start noting the relative brightness of the planet's rings compared to its disc. Over the next evenings, the rings will slowly brighten to a peak at opposition on 14 August.

Thursday 11 ▶

Moonwatch this month takes in the albedo feature Reiner Gamma, a bright swirl on the surface of Oceanus Procellarum. Unlike relief features, which require oblique lighting to see at their best, albedo features are best seen around full Moon.

◀ Saturday 13

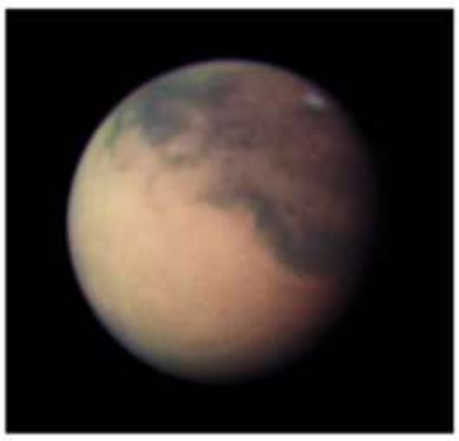
This morning plays host to the peak of the Perseid meteor shower. However, the presence of a just-past-full Moon in Aquarius will render this year's visual peak unfavourable.

Monday 15

This morning's 87%-lit waning gibbous Moon lies 6° from mag. –2.6 Jupiter.

Friday 19 ▶

Magnitude 0.0 Mars sits 5.7° south of the Pleiades open cluster this morning. As the sky begins to brighten, the last quarter Moon will also be nearby, sitting a fraction less than 4° from Mars.



Saturday 20

A 41%-lit waning crescent Moon, magnitude 0.0 Mars and the Pleiades form an isosceles triangle this morning, an attractive sight if you have clear skies.

PETE LAWRENCE X 7

◀ Thursday 25

A 4%-lit waning crescent Moon sits 3° north of the Beehive Cluster, M44, very low above the east-northeast horizon just before dawn. View from around 04:00 BST (03:00 UT). 40 minutes later, mag. –3.8 Venus appears.

Friday 26

A 1%-lit waning crescent Moon lies 4.5° northeast (left as seen from the UK) of mag. –3.8 Venus this morning. Catch them together from 05:00 BST (04:00 UT).

Thursday 4

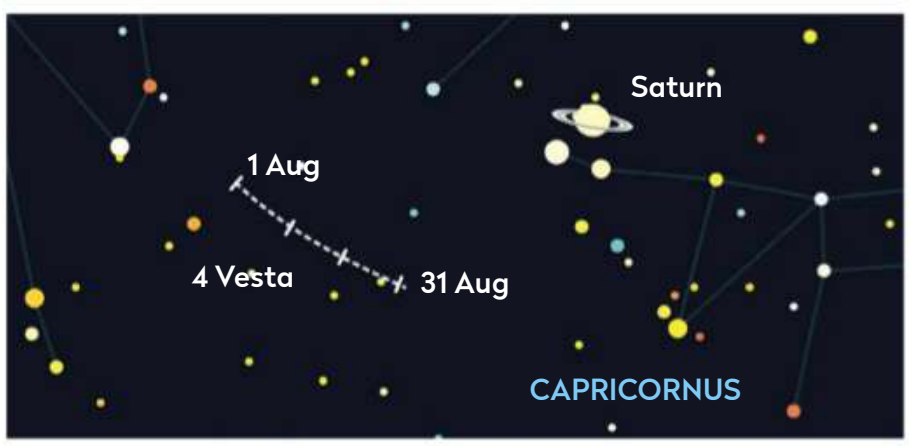
The clair-obscur effects known as the lunar X and V will be visible on the terminator of this afternoon's 42%-lit waxing crescent Moon. The effects will be formed around 19:20 BST (18:20 UT) when the Moon is just to the west of south in the daytime sky.

Friday ▶ 12

The full Moon lies 5.1° south of mag. +0.3 Saturn in the early hours of this morning. Catch the pairing as darkness falls on 11 August until closest just before moonset at 05:30 BST (04:30 UT) on 12 August.

Sunday 14

The planet Saturn reaches opposition today, a time when its rings should appear at their brightest due to the so-called 'opposition effect'.



◀ Tuesday 23

Minor planet 4 Vesta reaches opposition at mag. +6.0. For more details and a full chart, see our Comets and Asteroids section on page 53.

Sunday 28

Catch a very thin and beautiful 2%-lit waxing crescent Moon low above the west horizon just after sunset this evening. The Moon sets approximately 50 minutes after the Sun.

Family stargazing

The Lunar X and V are popular clair-obscur effects – basically tricks of the light which create shapes and patterns on the Moon's surface. Here the letters 'X' and 'V' appear within the complex shadow-play near the lunar terminator. They appear for just a few hours and should be visible on the evening of 4 August around 19:20 BST. A small telescope is recommended for this. Point it at the Moon located in the daytime sky at the time mentioned and ask your young observers to try to find both letters. **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

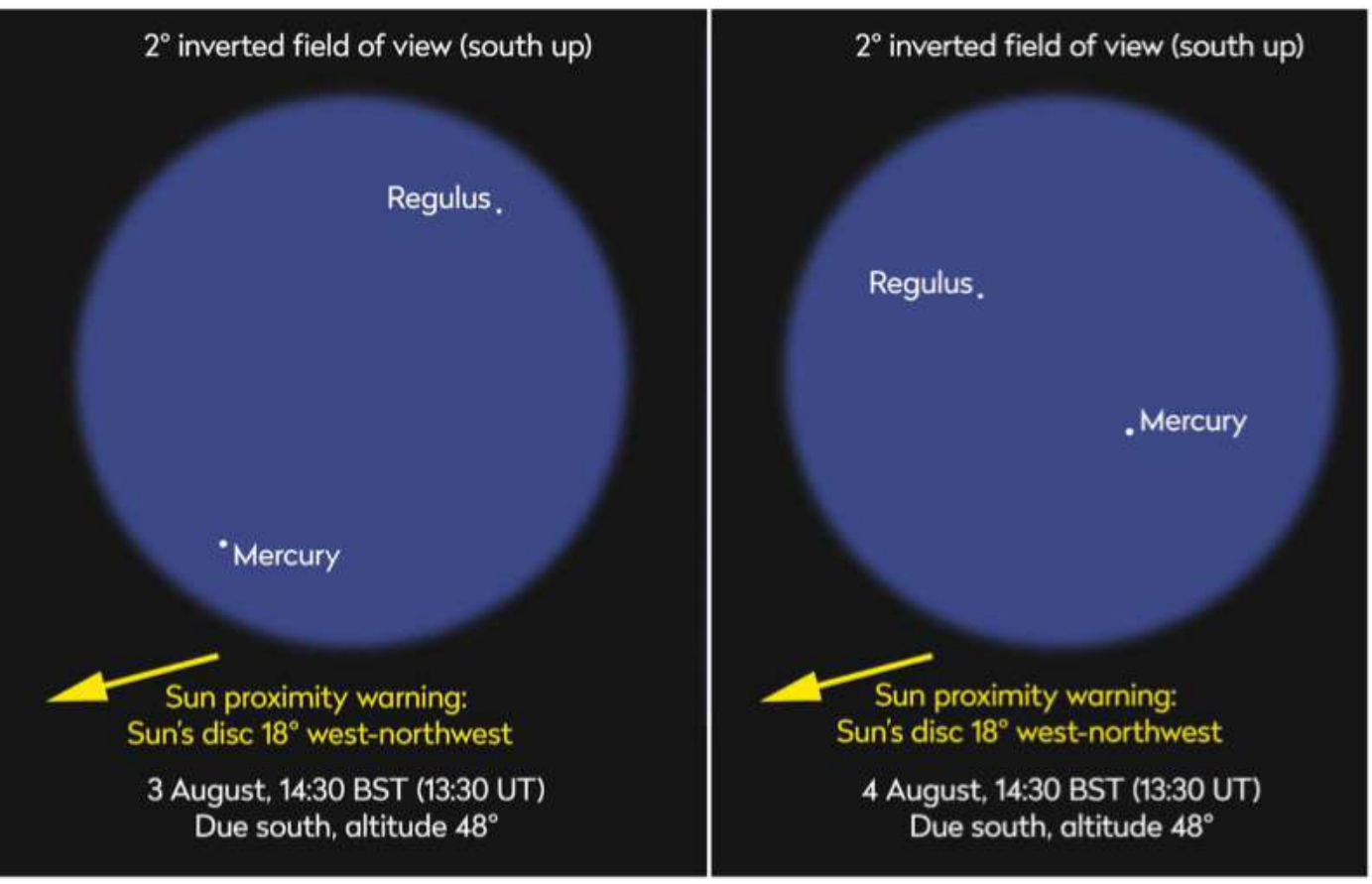
GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

Mercury and Regulus – a daytime target

BEST TIME TO SEE: 3 and 4 August around 14:30 BST (13:30 UT)



▲ **Can you find Mercury and Regulus under daylight conditions on 3 and 4 August?**

Although nights are slowly getting longer, there's an awful lot of day to contend with too. An interesting opportunity occurs at the start of August, when Mercury appears close to the brightest star in Leo the Lion, Regulus. This will be nigh on impossible to see after sunset due to low altitude, so other arrangements need to be made.

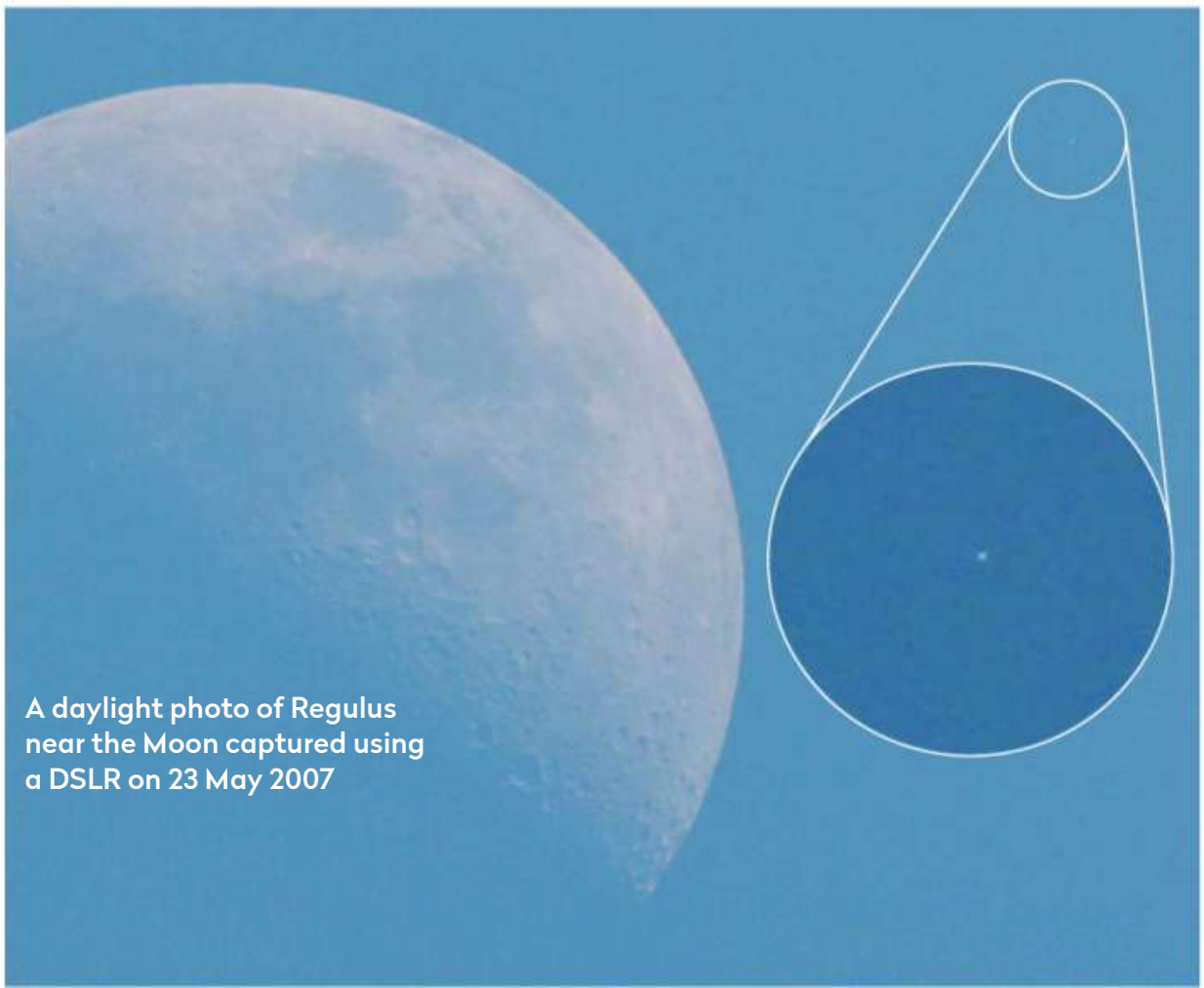
Mercury will shine at mag. –0.4 on 3 August and –0.3 on 4 August, bright enough for the planet to be seen in daylight, as long as you know where to look. Regulus shines at mag. +1.3 but, being a point source of light, can also be seen during the day. Consequently, if your telescope is pointing at the right place in the sky, you should be able to see both Mercury and Regulus together in broad daylight.

At 14:30 BST (13:30 UT) on 3 August, Mercury is due south at an altitude of 50° from the centre of the UK. At this time, the planet is located 1.6° from Regulus. At the same time on 4 August, the pair are in a similar sky position, separated by 44 arcminutes.

Closest separation occurs earlier that morning at 10:00 BST (09:00 UT), when planet and star are just 40 arcminutes apart. There are various ways to locate Mercury during the day. If you have a Go-To telescope set up the night before, it should locate Mercury easily. If this isn't an option, and if your Go-To allows you to sync on the Sun, it can be used as a jumping-off point – as long as you remember to filter the telescope and cap any finders.

If your mount has setting circles, an appropriately filtered view of the Sun can be used to locate Mercury manually. Here, with the solar filter fitted, centre on the Sun accurately, focusing on its disc. Look up the Sun's RA and dec., adjusting the setting circles to match. Look up the coordinates for Regulus and slew the telescope to that position. Check the Sun is out of the field of view (it should be 18° to the west), remove the filter and look for the planet.

As ever with daylight observing, please take great care not to allow the Sun anywhere near your telescope's field of view when you are looking through the eyepiece. If you do navigate to the target using the Sun as a jumping-off point, make sure you have all optics protected with the appropriate filters or safety caps.



A daylight photo of Regulus near the Moon captured using a DSLR on 23 May 2007

ALL PICTURES: PETE LAWRENCE

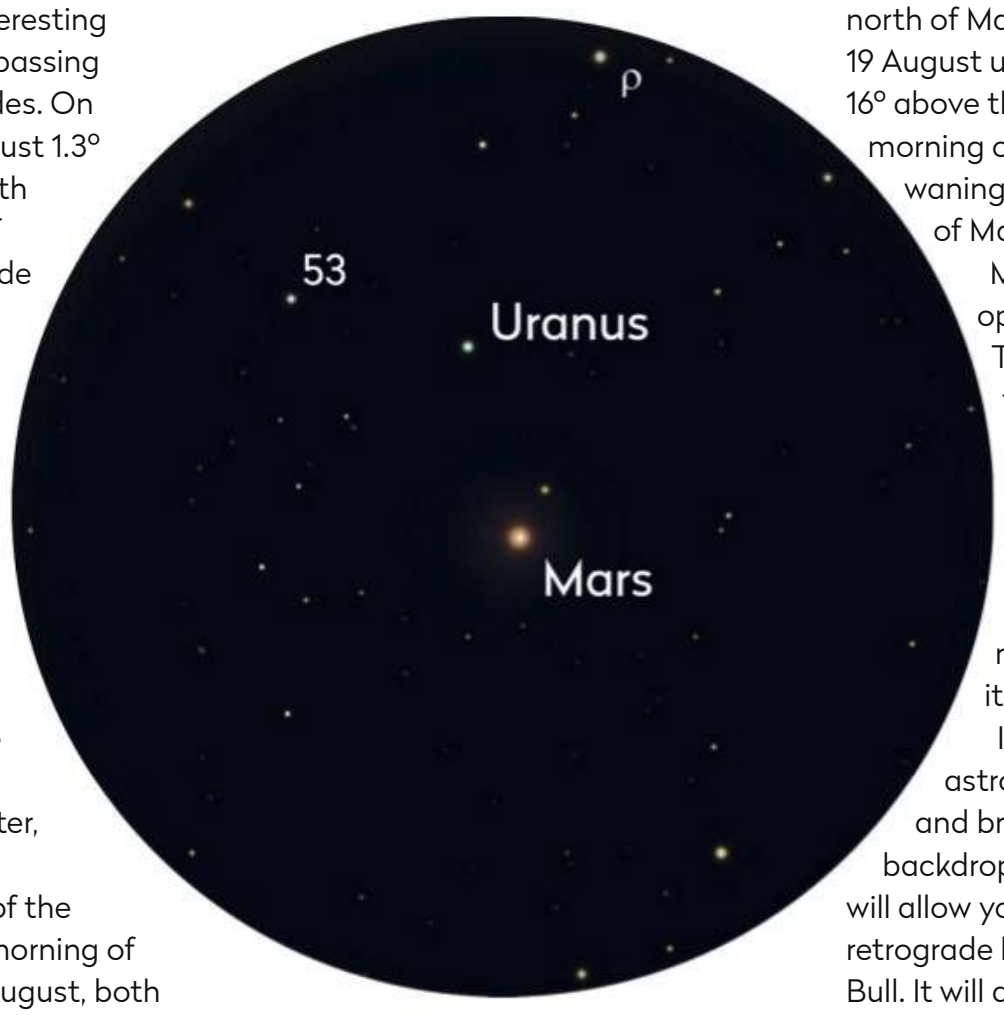
Mars, Uranus and the Pleiades

BEST TIME TO SEE: Mornings of 2 and 19–23 August

Mars has a couple of interesting encounters this month, passing close to Uranus and the Pleiades. On 2 August, mag. +0.2 Mars sits just 1.3° south of mag. +5.8 Uranus. Both planets rise around 00:00 BST (23:00 UT) and reach an altitude of 25° above the eastern horizon as the darkest part of the night comes to an end at around 03:00 BST (02:00 UT).

Mars slowly drifts east from Uranus over the following mornings, but remains fairly close to the dimmer planet for several days. On 5 August, for example, Mars and Uranus are 2.3° apart.

After this planetary encounter, Mars continues tracking east, appearing to pass 5.7° south of the Pleiades open cluster on the morning of 22 August. Before this, on 19 August, both planet and cluster are joined by the last-quarter Moon, located 5° west of Mars on this date. The Moon will pass 2° north of Mars at 13:00 BST (12:00 UT) on 19 August under daylight conditions, while 16° above the western horizon. On the morning of 20 August, the now 41%-lit waning crescent Moon sits 7.7° east of Mars.



▲ A simulation of the planets through 7x50 binoculars at 2 August, 02:00 BST (01:00 UT). The variable runaway star 53 Arietis is close

Mars has now reached its opposition constellation of Taurus and will remain within this constellation's boundaries for the remainder of 2022 and into 2023. As it does this, it'll also be performing a retrograde loop, reversing direction to head west before repeating the action to resume its eastern track.

If you're interested in long-term astrophotography of the position and brightness of Mars against the backdrop of Taurus, the coming weeks will allow you to record and present the retrograde loop against the stars of the Bull. It will also offer an opportunity to compare the colour of Mars with the orange-tinted Aldebaran (mag. +0.8 Alpha (α) Tauri).

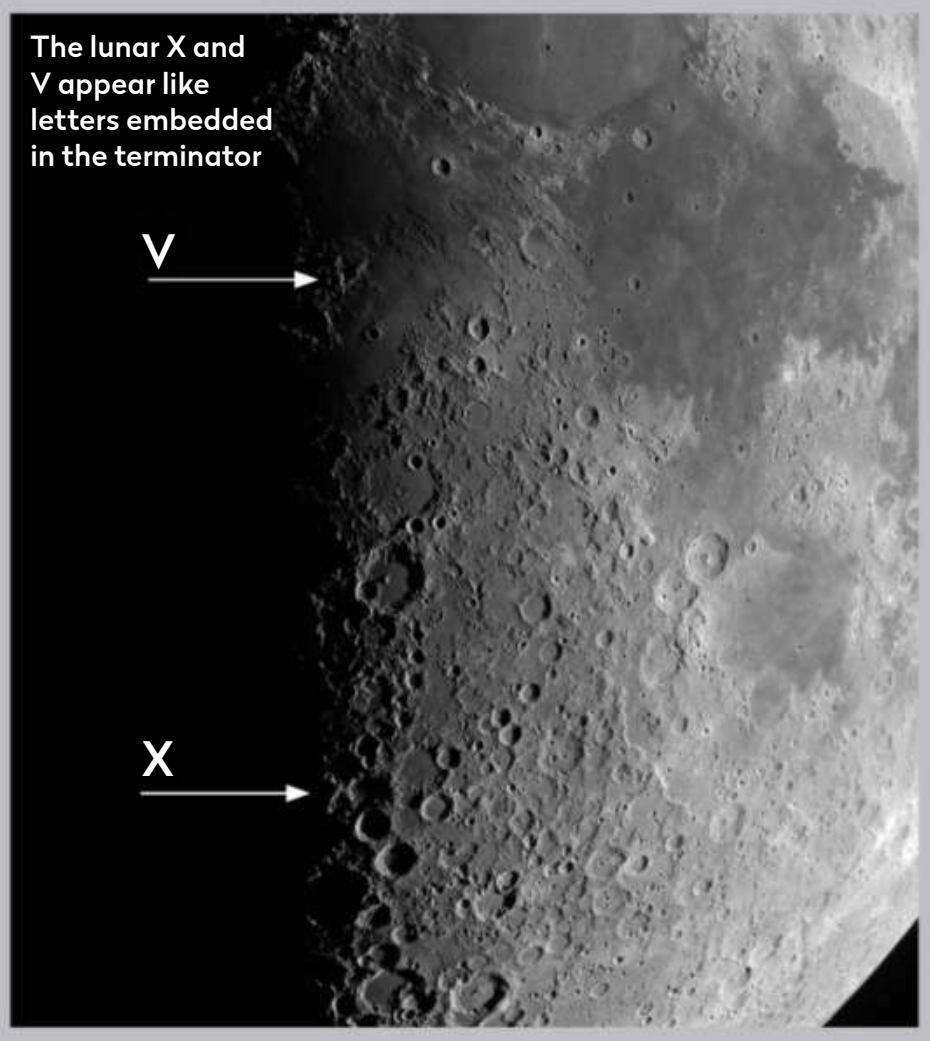
Lunar X and V

BEST TIME TO SEE: Evening of 4 August just before sunset

Another opportunity to see the popular lunar X and V clair-obscur effects occurs late in the afternoon on 4 August. The effects take place when the Sun is up, adding an extra element of difficulty in seeing them. The X and V appear in their letter forms near to the lunar terminator for a short period of just a few hours. On 4 August, they will appear optimally around 20:00 BST (19:00 UT) when the Moon is 20° above the south-southwest horizon. Sunset will be approaching.

The V forms when the lunar dawn's early light illuminates elevated features near to the 23km crater Ukert, which appears just above the central point of the Moon's disc on 4 August. Similarly, the lunar X is formed when rim sections of three craters 58km Blanchinus, 68km La Caille and 118km Purbach catch the lunar dawn.

Contrast will be reduced for both effects because of the daylight conditions, but using a small telescope, it should still be possible to see them. If you're into imaging, consider using an infrared sensitive mono high-frame-rate camera combined with an infrared pass filter.



The lunar X and V appear like letters embedded in the terminator

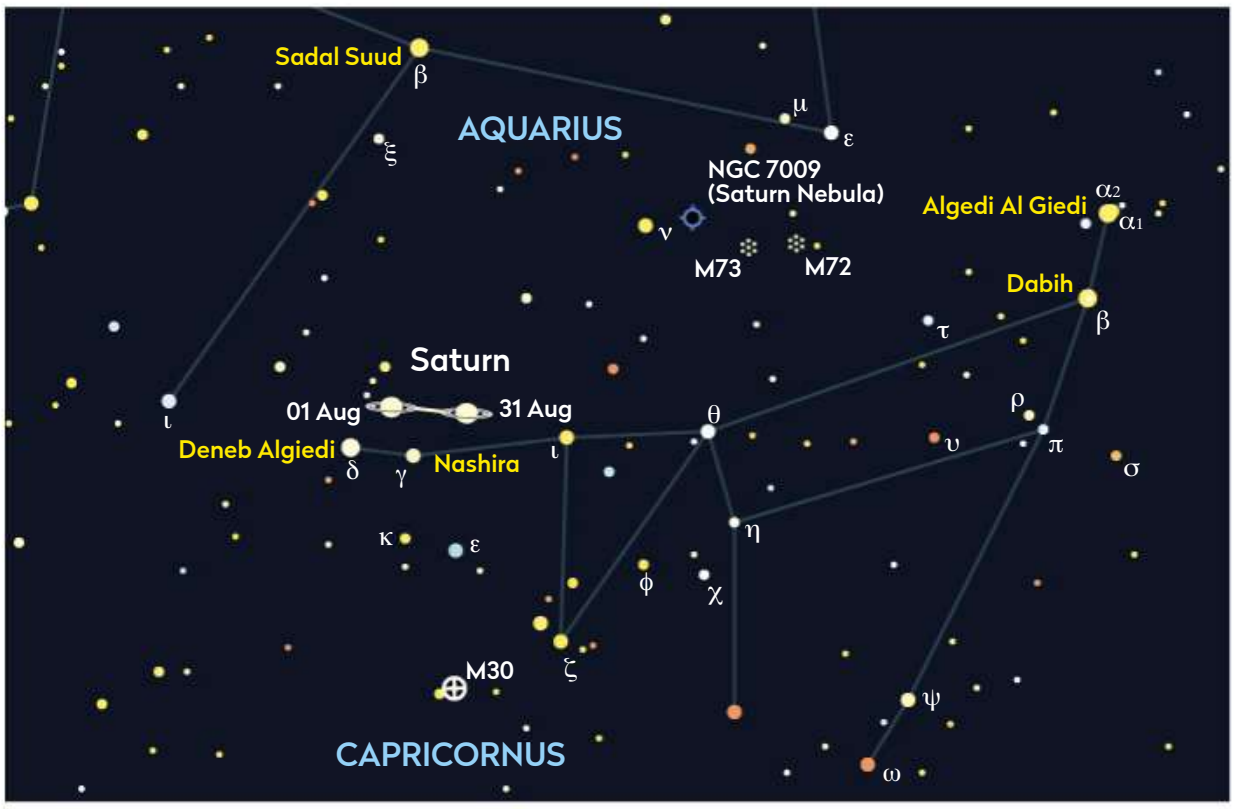
THE PLANETS

Our celestial neighbourhood in August

PICK OF THE MONTH

Saturn

Best time to see: 14 August, 00:00 UT
Altitude: 22° (low)
Location: Capricornus
Direction: South
Features: Rings, banded atmosphere, weather systems
Recommended equipment: 75mm or larger



▲ **Saturn is currently in Capricornus, not too far from mag. +8.0 planetary nebula NGC 7009**

Saturn reaches opposition on 14 August, a time so-named because the planet is in the opposite part of the sky to the Sun. A view of Saturn in the week running up to opposition will show the rings getting brighter. In the week after opposition, the rings slowly appear to revert back to their normal brightness. This is due to what's known as the opposition effect, a phenomenon caused by the shadows of the ring particles being reduced to a minimum as seen from Earth at opposition.

As has been the case for several years now, it's Saturn's north pole which is angled towards us. The tilt angle is slowly decreasing year on year, with minor variations within each year. Through August it changes from +13.3 to +14.3, which is low enough to keep the north-south extremes of the rings well within the boundaries of the planet's globe. At present they extend to a point roughly half-way between the apparent centre and poles of the planet.

At opposition Saturn manages a peak brightness of mag. +0.3 and is above the horizon from when the sky begins to darken to when it brightens with the onset of dawn. The full Moon sits near to Saturn on the nights of 11/12 and 12/13 August.

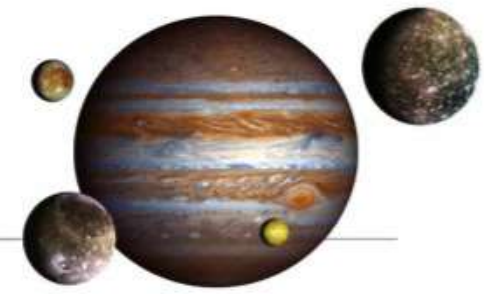
▲ **At opposition, Saturn's rings glow brighter than usual (right-hand half)**

Saturn's declination is slowly increasing which means it's getting higher in UK skies. This is a good thing as far as viewing the planet goes, as Saturn will appear less affected by low-level atmospheric turbulence. Through a telescope, the rings are the most obvious feature, but attention should be made to look for variations on the disc as well. As well as subtle banding, bright patches representing storms may sometimes be seen as well.

PETE LAWRENCE X 2

The planets in August

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 1 August, 30 minutes after sunset
Altitude: 2° (extremely low)
Location: Leo
Direction: West-northwest
On 1 August, Mercury shines at mag. –0.5 but sets just 40 minutes after the Sun. At greatest eastern elongation on 27 August, despite an impressive 27.3° separation from the Sun, the mag. +0.3 planet sets 30 minutes after sunset and is unlikely to be seen.

Venus

Best time to see: 1 August, 30 minutes before sunrise
Altitude: 11°
Location: Gemini
Direction: East-northeast
On 1 August, Venus rises 120 minutes before the Sun and shines at mag. –3.8. By 31 August it rises 90 minutes ahead of the Sun.

Through a telescope, Venus appears as an almost full circle at the end of the month, 97%-lit and 10 arcseconds across. A slender 4%-lit waning crescent Moon lies 9° above Venus, as seen from the UK, on the morning of 25 August and as a very thin 1%-lit waning crescent 4.3° from Venus on the morning of 26 August.

Mars

Best time to see: 31 August, 04:00 UT
Altitude: 51°
Location: Taurus
Direction: Southeast
Mars starts the month at mag. +0.2, 1.3° to the south of mag. +5.8 Uranus, then passes 5.9° south of the Pleiades open cluster on the morning of 18 August. The last quarter Moon sits near to the planet on the morning of 19 August. Mars reaches the mag. 0.0 threshold on 21 August. Through a telescope, the planet increases in apparent size from eight arcseconds on 1 August to nine arcseconds on 31 August.

Jupiter

Best time to see: 31 August, 02:00 UT
Altitude: 38°
Location: Cetus
Direction: South
Jupiter is improving as it approaches opposition next month. By mid-August it reaches its highest point in the sky, due south in darkness. On 15 August, mag. –2.6 Jupiter is joined by an 87%-lit waning gibbous Moon. By the end of August, the planet brightens to mag. –2.7 in Cetus, right on the border with Pisces.

Uranus

Best time to see: 31 August, 03:00 UT
Altitude: 49°
Location: Aries
Direction: South-southeast
On the morning of 2 August, mag. +0.2 Mars is located 1.3° south of mag. +5.8 Uranus. By the end of August, now at mag. +5.7, Uranus is able to reach an altitude of 50° under truly dark skies.

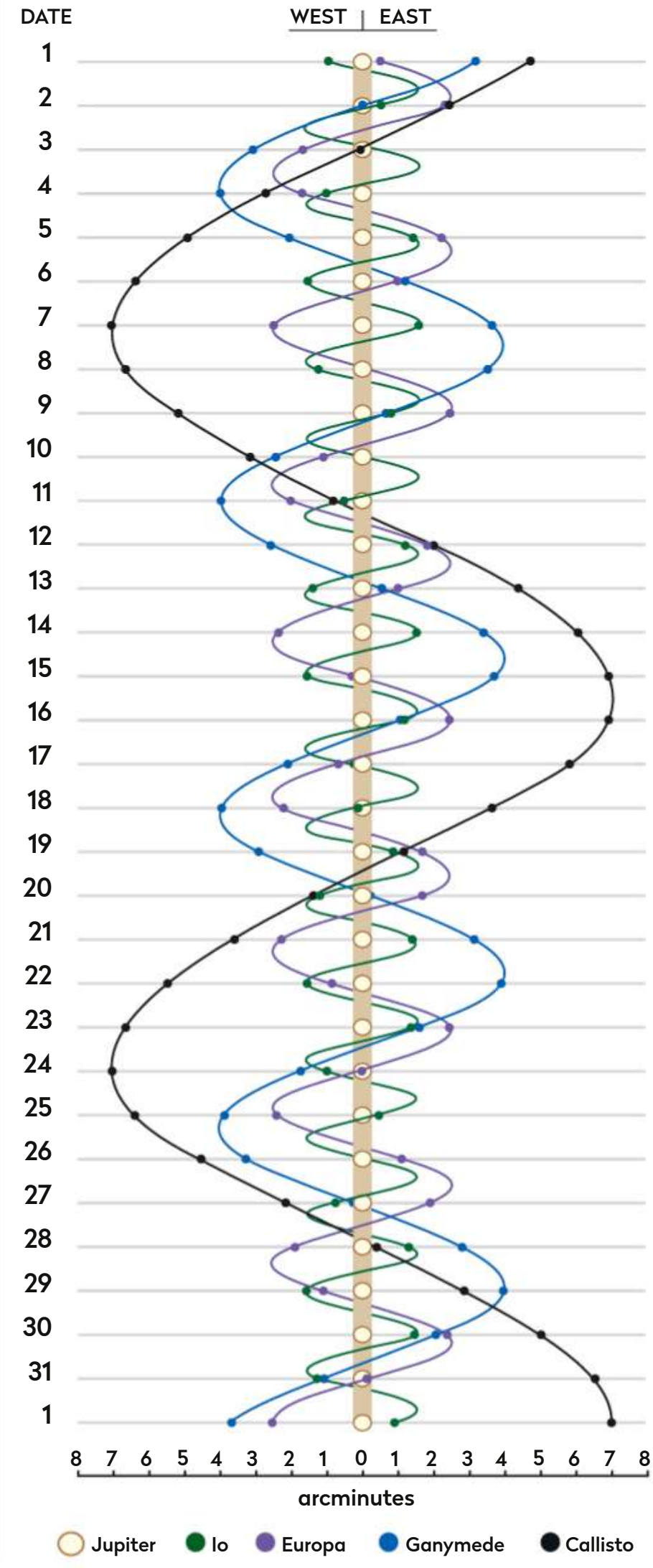
Neptune

Best time to see: 31 August, 01:15 UT
Altitude: 34°
Location: Aquarius
Direction: South
Neptune slips across the border from Pisces into Aquarius on 18 August. At mag. +7.8, the planet is technically visible to the naked eye, but can be challenging. Reaching opposition next month, Neptune is very well placed for UK observation.

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: AUGUST

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT.)



THE NIGHT SKY – AUGUST

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- 5° N E W S — COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 August at 01:00 BST
15 August at 00:00 BST
31 August at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in August*

Date	Sunrise	Sunset
1 Aug 2022	05:26 BST	21:06 BST
11 Aug 2022	05:43 BST	20:47 BST
21 Aug 2022	06:00 BST	20:25 BST
31 Aug 2022	06:17 BST	20:02 BST

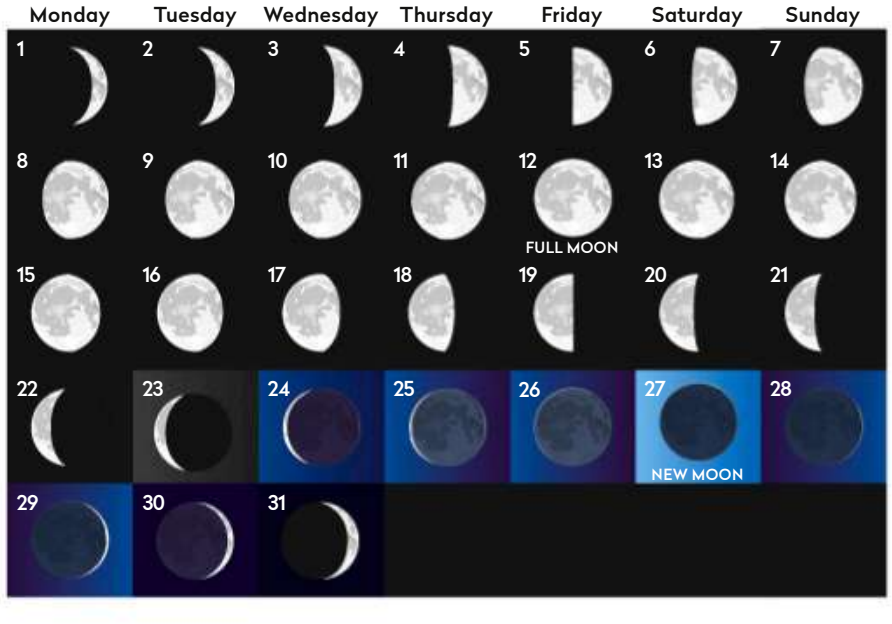
Moonrise in August*

Moonrise times

1 Aug 2022, 09:16 BST	17 Aug 2022, 22:38 BST
5 Aug 2022, 14:33 BST	21 Aug 2022, --:-- BST
9 Aug 2022, 19:58 BST	25 Aug 2022, 03:16 BST
13 Aug 2022, 21:50 BST	29 Aug 2022, 08:21 BST

*Times correct for the centre of the UK

Lunar phases in August



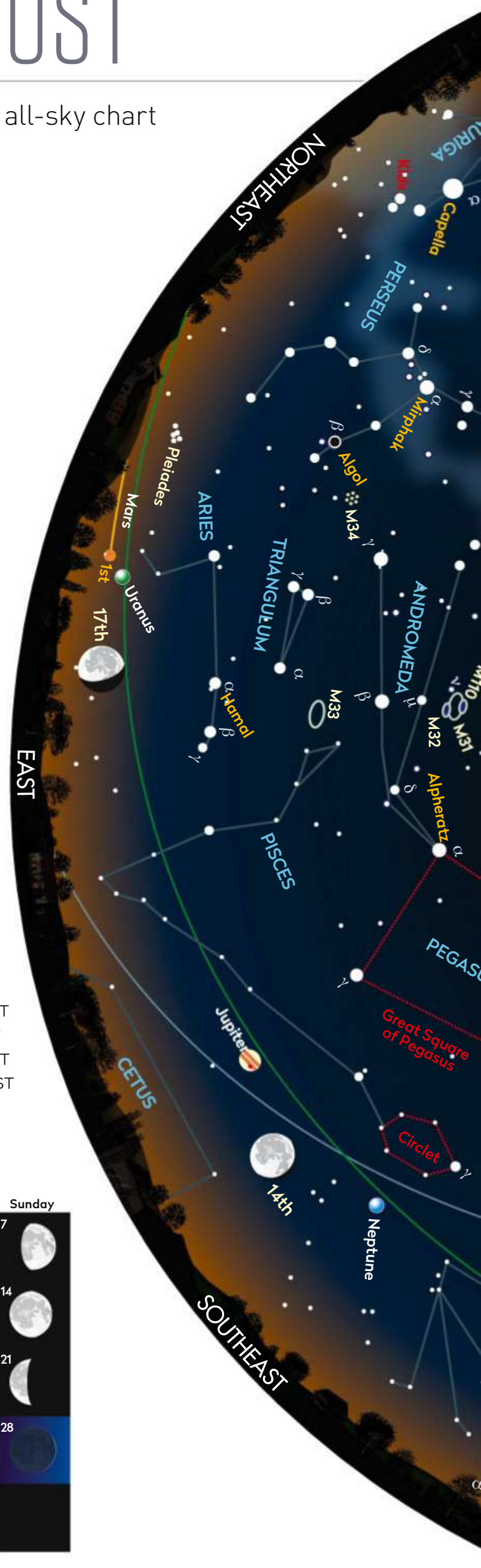


CHART: PETE LAWRENCE

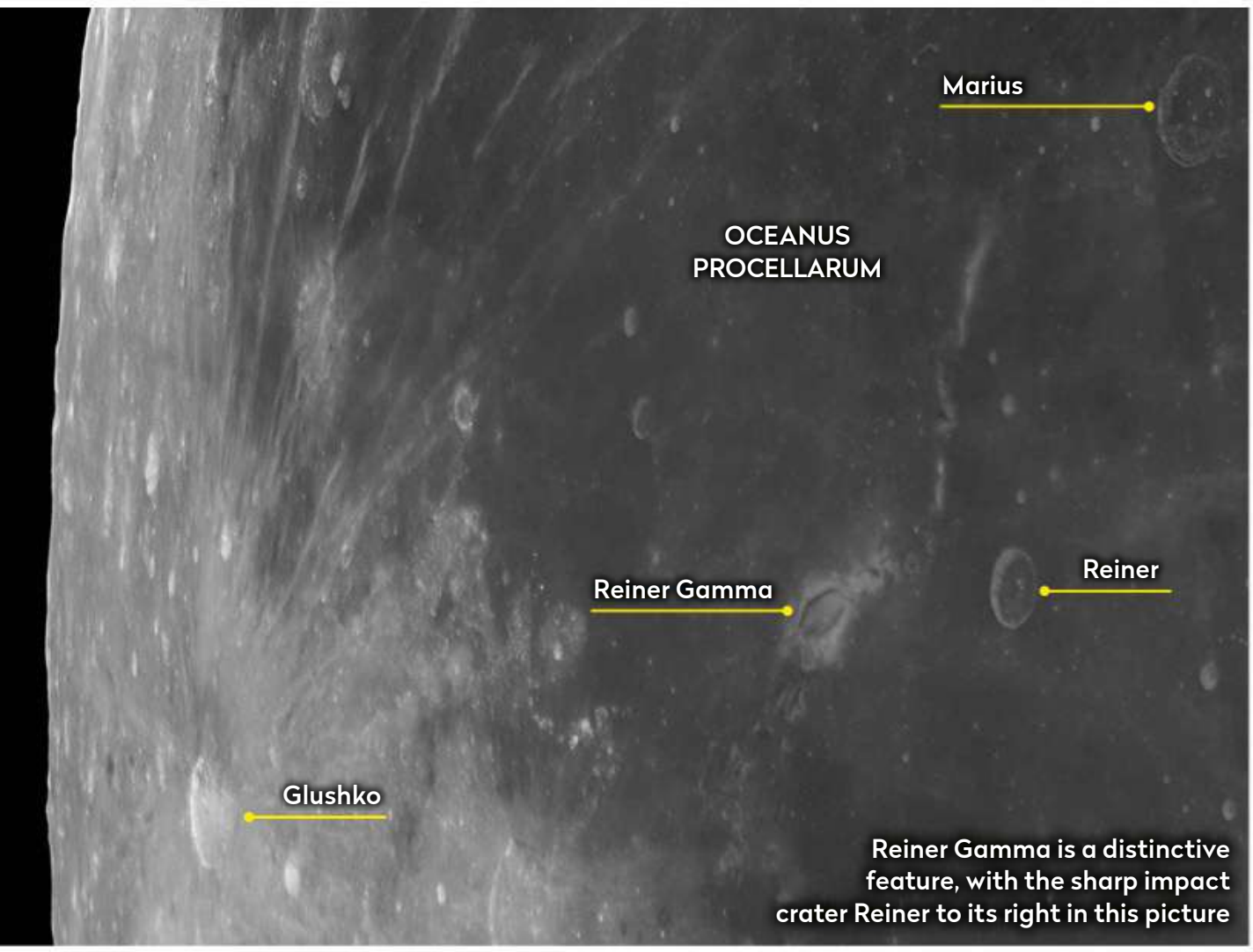
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

August's top lunar feature to observe

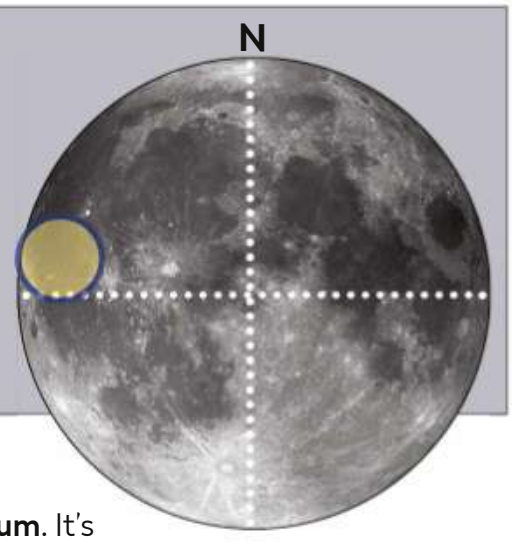


Reiner Gamma is a distinctive feature, with the sharp impact crater Reiner to its right in this picture

PETE LAWRENCE X 3

Reiner Gamma

Type: Lunar swirl
Size: 40x30km
Longitude/Latitude: 59° W, 7.4° N
Age: Less than 1.1 billion years
Best time to see: Full Moon until three days after last quarter (11–22 August)
Minimum equipment: 50mm refractor



Reiner Gamma is an enigmatic albedo feature visible in the **Oceanus Procellarum**. It's classed as a **lunar swirl**: a high albedo, youthful feature which typically has a curving or sinuous shape. Lunar features divide into two categories, relief and albedo. **Relief features** have height, and examples include mountains, hills and crater rims, but the height doesn't need to be upward: deep crater floors, valleys and rilles also count as relief features. The chief characteristic of a relief feature is that it will cast shadows when lighting is oblique. At times when the lighting is directly from above, such features may virtually disappear from view.

Albedo features are visible due to the reflective characteristics of the material which forms them. The most obvious albedo features visible from Earth are the lunar seas, the lava of their surfaces seeming darker than the surrounding lunar highlands.

The young material which forms the swirl known as Reiner Gamma is visible because it has a higher reflectivity (albedo) than the dark lava of Oceanus Procellarum on which it sits. It's a curious feature which lacks any height, and this is very evident when the Sun is low in its sky, because it casts no shadows. It appears like a stain on Procellarum's surface, the central portion (the part that's named **Reiner Gamma**) being eye-shaped with swirling patterns surrounding it.

The patterns continue east for a distance of around 60km before heading in a pseudo-linear fashion to the north-northeast. A similar extension emanates to the southwest of the 'eye' but is less well defined than the north-northeast streak.

Various explanations have been put forward for the formation of lunar swirls, which always tend to be located in regions showing **magnetic field anomalies**. Theories include the swirls being formed when a comet impacts the lunar surface, or perhaps young and bright surface material being shielded by the darkening effects of solar wind space weathering. Another theory describes fine, **high-albedo dust particles** being lifted above the lunar surface electrostatically, to be deposited within the magnetic anomaly regions.

Measurements of the magnetic field from a height of 28km above Reiner Gamma report a strength of 15nT (15 nanoteslas), one of the strongest magnetic anomalies known on the Moon. This field strength is sufficient to create a localised **magnetosphere** which would act like a 360km diameter shield over the swirl, perhaps explaining why it looks so fresh in definition.

The actual formation mechanism remains a bit of a mystery to this day. Some other swirls are located at the diametrically opposite point on the lunar surface from a major impact zone. However, there seems no such feature which could have resulted in seismically focused energy to lift surface material on the other side of the Moon to form Reiner Gamma.

Theories include the swirls being formed when a comet impacts the lunar surface

The feature gets its name from the 30km crater **Reiner** which lies 120km to the east. Reiner is foreshortened into an oval as we see it from Earth, but is well defined with a sharp rim which leads steeply down to a level floor. The floor has a bump in the centre and appears malformed in its southern half, with a curious, almost folded cleft line running north–south.

COMETS AND ASTEROIDS

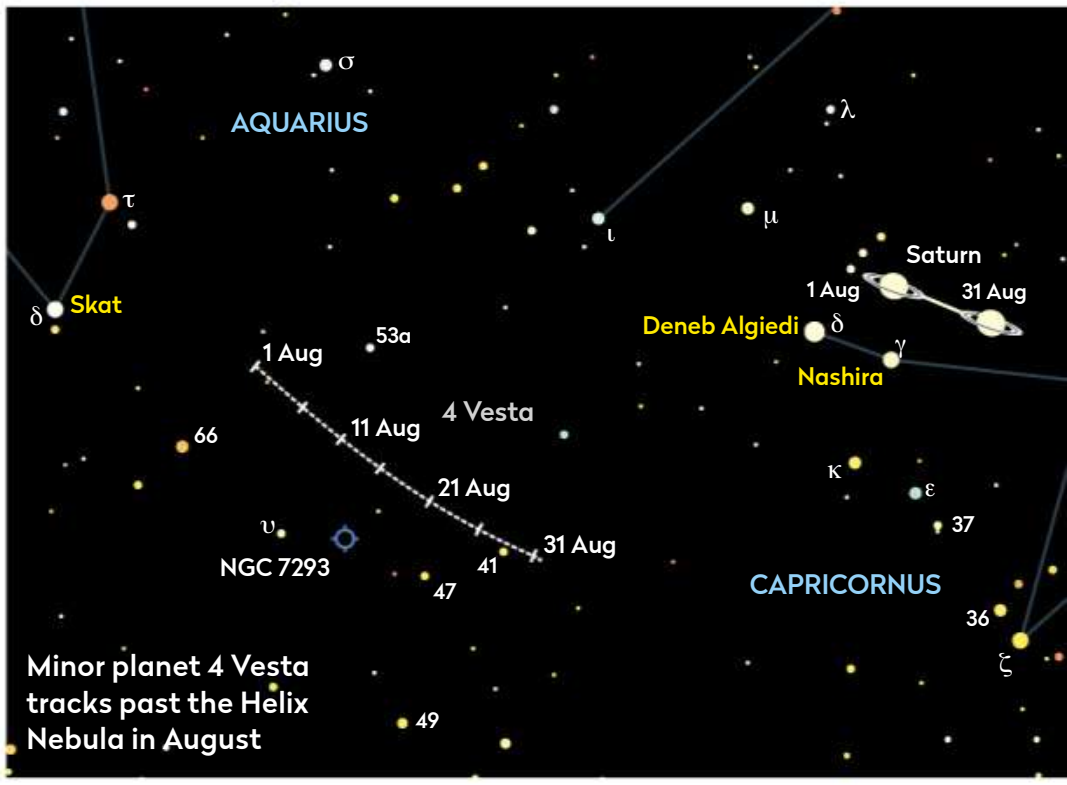
One of the largest objects in the asteroid belt, 4 Vesta reaches opposition

Asteroid 4 Vesta has the potential to appear the brightest of the minor planets, reaching a respectable mag. +5.1 when it's at a favourable opposition, easily visible to the naked eye from a dark-sky location. Vesta reaches opposition on 23 August and although not quite as bright as it can get, it will be on the threshold of naked-eye visibility from a dark sky site at mag. +6.0.

Vesta is currently located in southwest Aquarius, east of Saturn and triangular-shaped Capricornus, tracking in a southwest arc above NGC 7293, the Helix Nebula. One of the closest planetary nebulae to Earth, the Helix appears large with a very low surface brightness. Its inner ring is 8x19 arcminutes in size, extending out to appear almost 25 arcminutes across. Vesta begins the month 5° north-northeast of the Helix, ending the month 5° to the west of it. Use mag. +3.3 Delta (δ) Aquarii as the navigational starting point at the beginning of the month.

Vesta appears as a mag. +6.4 object on 1 August, brightening to its opposition magnitude of +6.0 on 18 August, a value it maintains through to 25 August. By the end of the month it will have dimmed to mag. +6.2, but is still an easy binocular target.

Vesta was discovered on 29 March 1807 by Wilhelm Olbers. As its prefix number suggests, it was the fourth minor planet discovered. It's a large example, only beaten in size by dwarf planet Ceres. It completes an orbit of the Sun once every 3.63 years, its orbital path taking it out as far as 2.57 AU and in as close as 2.15 AU. Interestingly, its size combined with its varying distance from Earth means it presents an angular diameter that varies between 0.2 and 0.7 arcseconds.



Minor planet 4 Vesta tracks past the Helix Nebula in August

STAR OF THE MONTH

Sadr, on the edge of the Cygnus Rift

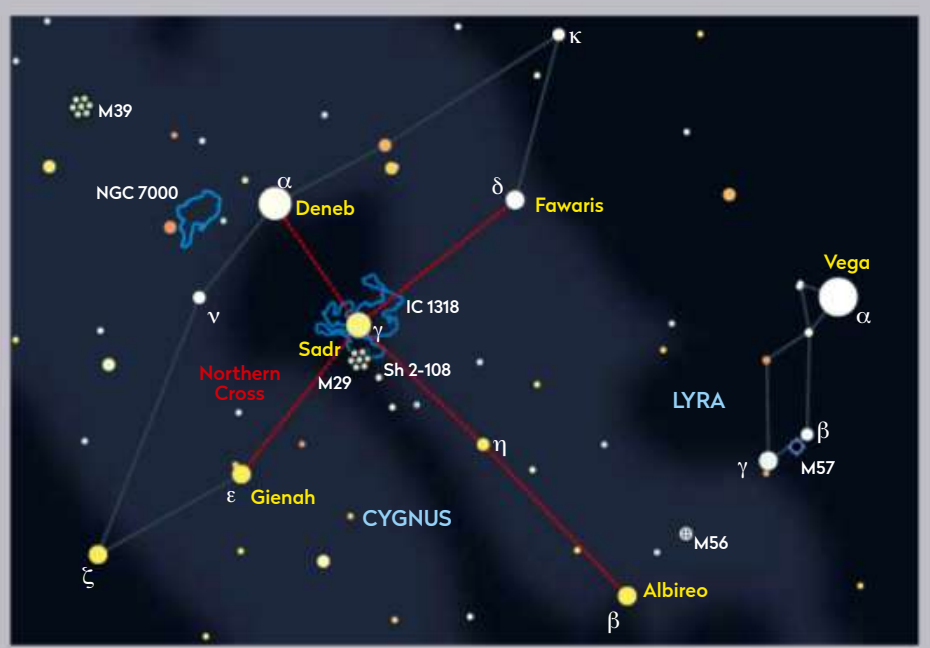
Sadr (Gamma (γ) Cygni) is really easy to identify as it sits at the heart of the large summer asterism known as the Northern Cross, the core portion of Cygnus, the Swan. The name is pronounced 'sadder' and means 'chest', a reference to where it sits within the Swan. Despite the gamma label, at mag. +2.2, Sadr is the second-brightest star in Cygnus after mag. +1.3 Deneb (Alpha (α) Cygni).

Sadr is a popular target for summer observing as it sits within a bright portion of the Milky Way, on the edge of a dark region known as the Cygnus Rift, where the Milky Way appears to split in two. The apparent split is caused by a dark dust cloud between us and the myriad stars in the disc of the Milky Way. Sadr itself is also affected by the dust: it dims the star's light by around half a magnitude.

Sadr is a supergiant with a spectral classification of F8 Iab. This puts it in the yellow-white category, more towards the yellow end, while 'Iab' indicates it's an intermediate-size luminous supergiant. For nearly 80 years, Sadr's spectrum has been used as a stable reference point to classify other stars against.

Physically, Sadr is 150 times larger than our Sun, contains 12 times as much mass and is emitting 33,000 times more energy. Consequently, Sadr is

▼ **The centre of Cygnus's cross is an interesting region, with the bright open cluster M29 visible**



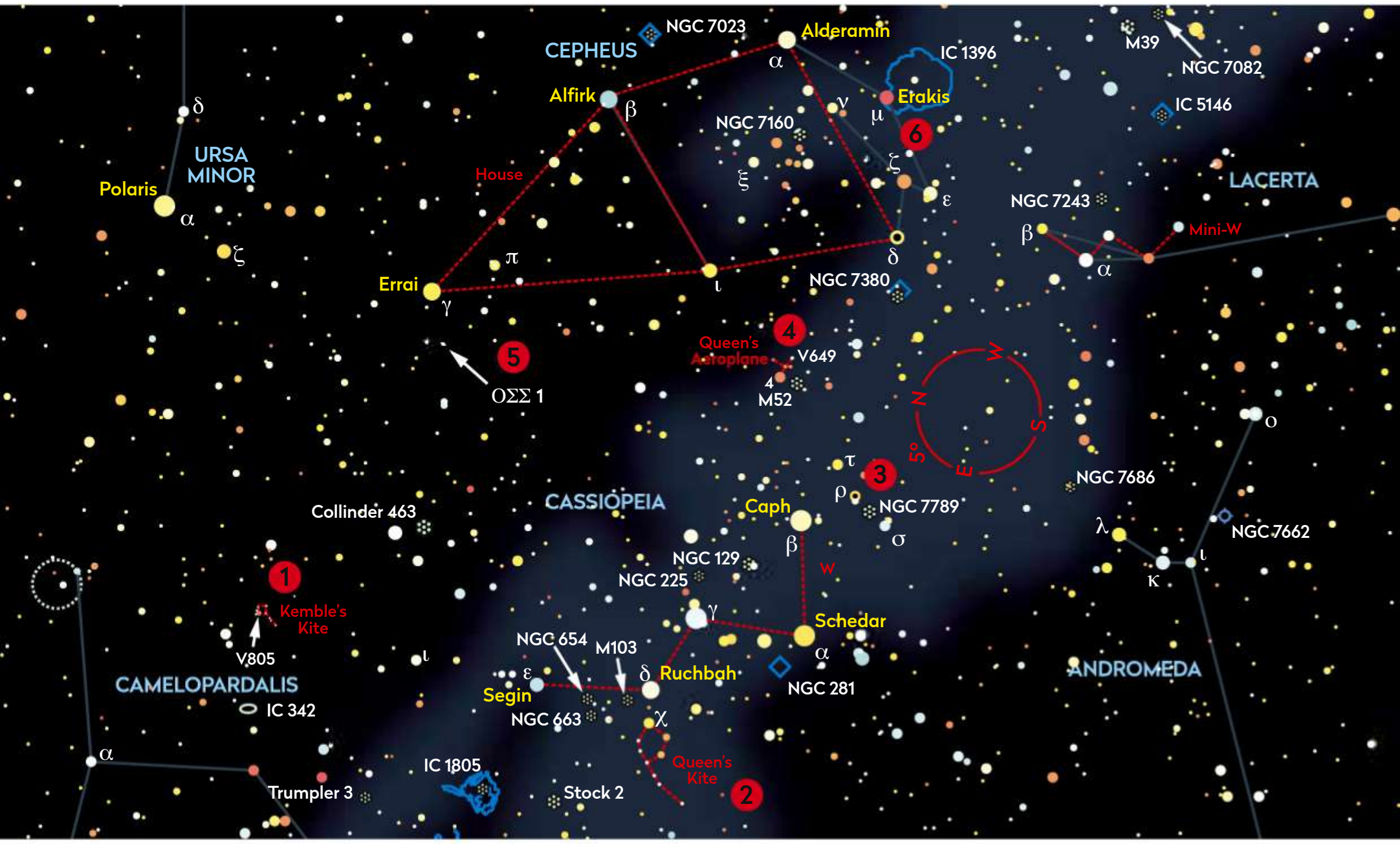
thought to be fairly young, at around 12 million years old. It's estimated to lie around 1,800 lightyears from the Sun.

The region around Sadr contains IC 1318, a complex diffuse nebula emitting strongly at hydrogen alpha wavelengths. As a result, the region is popular for long-exposure photographs, with Sadr at the centre.

BINOCULAR TOUR

With Steve Tonkin

The sky is full of kites and aeroplanes, but don't forget the massive stars too



1. Kemble's Kite

15x 70 Take a line from mag. +3.4 Segin (Epsilon (ε) Cassiopeiae) through mag. +4.6 Iota (ι) Cassiopeiae and extend it another 7° to mag. +6.4 V805 Cassiopeiae, which will look a deep yellow in your binoculars. It is the brightest of a 1.5°-long asterism of 10 stars of mag. +8.5 and brighter in the form of a diamond kite. The Kite has an easily splittable double star at its northern tip and a tail flowing southwards towards Perseus. ☐ **SEEN IT**

2. The Queen's Kite

10x 50 Our next target is even easier. Locate mag. +4.7 Chi (χ) Cassiopeiae which is the brightest of a pentagon of stars that surrounds a mag. +7.3 star 0.75° to the southeast. The tail extends southward for more than 2° from the most easterly star of this pentagon. Note the varied colours of the stars: the two brighter 'wing-tip' stars are yellow, while all the fainter ones are brilliant white. ☐ **SEEN IT**

3. Rho Cas

10x 50 Our next object, Rho (ρ) Cassiopeiae, is a yellow hypergiant. If it was where our Sun is, it would extend beyond the orbit of Mars! It normally varies between mag. +4.6 and +5.4, but every few decades it reddens and falls below 6th magnitude. This last happened 76 years ago, so is worth looking out for. ☐ **SEEN IT**

4. The Queen's Aeroplane

10x 50 Golden yellow mag. +5.0 star 4 Cassiopeiae marks the starboard wingtip of this small but colourful asterism of eight stars, all at mag. +8.0 or brighter. The other wingtip, a degree to the west, is mag. +6.6 blue-white V649 Cas. The curved 'fuselage' extends a degree northwards to a mag. +6.7 orange-red star. ☐ **SEEN IT**

5. OΣΣ 1

15x 70 You don't really need 70mm binoculars for our next target; it's easily visible in 20mm if you prefer, but the larger instrument brings out the colour contrast in this very pretty optical double star. Start at mag. +3.2 Errai (Gamma (γ) Cephei) and pan 2.5° towards Segin. Here is our widely separated (73 arcsecond) target. The brighter, mag. +7.2 member is orange-red, while the fainter, mag +7.7 companion is a yellowish white. ☐ **SEEN IT**

6. Herschel's Garnet Star

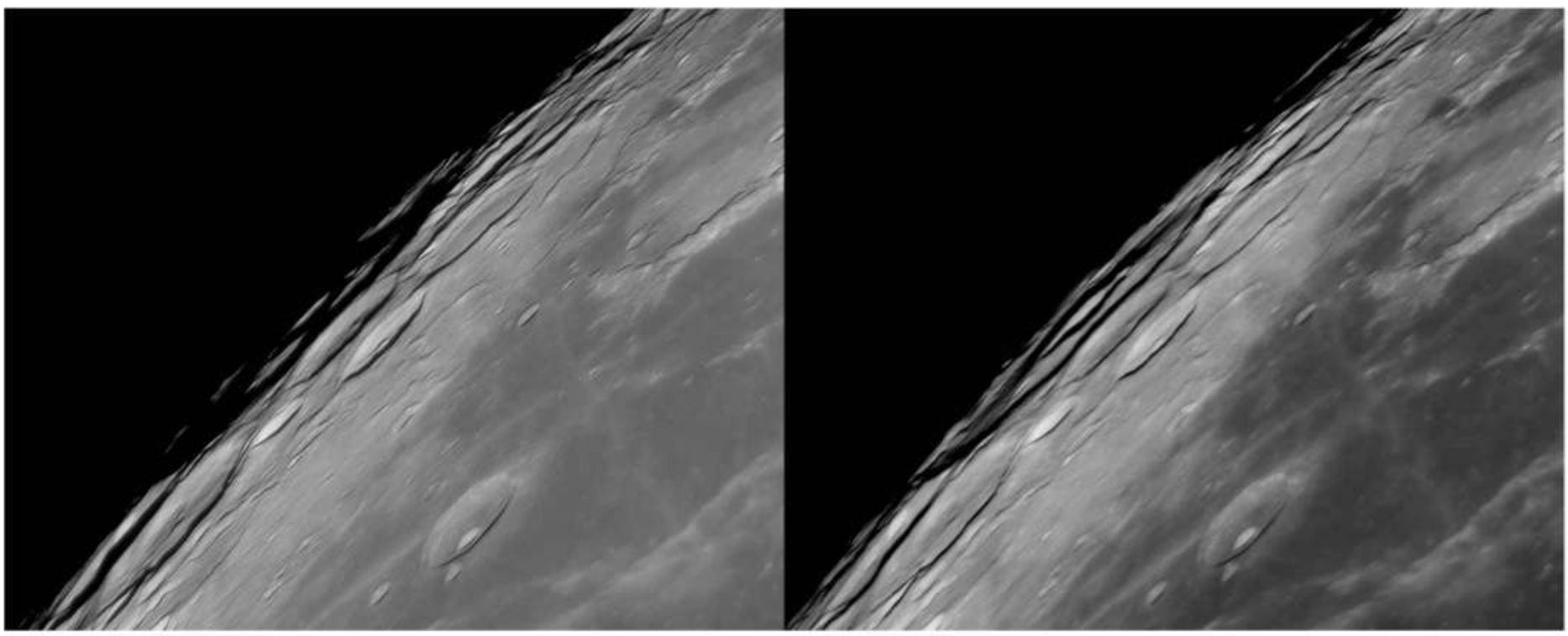
10x 50 The deep orange supergiant star, mag. +4.0 Mu (μ) Cephei is named for William Herschel, whose description is as apt today as it was when it was written more than 200 years ago: "a very fine deep garnet colour... a most beautiful object, especially if we look for some time at a white star before we turn to it." This is one of the largest known stars; Jupiter's orbit would easily fit inside it. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Observe and record the movement of shadows cast on the lunar surface



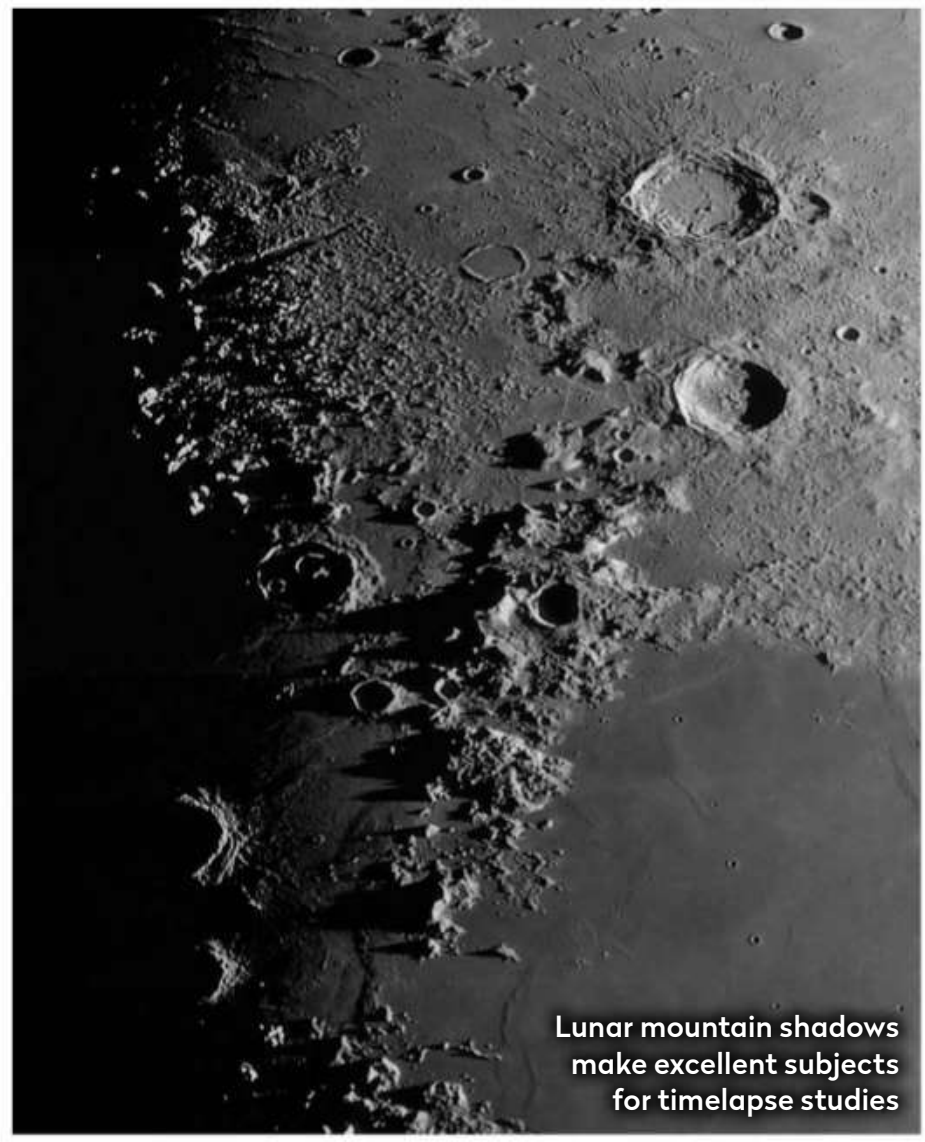
▲ Libration crater Einstein, on the western limb of the Moon. Two images four hours apart show significant shadow changes. These are the first and last shots from a 12-frame capture with 20-minute intervals between exposures, making the illumination differences clear

The Moon appears to move by an average of 13.2° against the background stars every day, a consequence of its orbital movement around the Earth–Moon centre of gravity or barycentre. This movement changes the Sun–Moon–Earth angle and consequently the position of the terminator on the lunar globe. Over the course of a synodic month (29.53 days) the morning or evening terminator will have moved completely around the globe. This month's challenge is to see and record a hint of that movement.

This would be hard to witness in a widefield view of the Moon which shows you the whole disc, but it's much easier to see using a magnified view. The Moon presents the best shadows near the terminator, the line dividing lunar day from night. Here the shadows are exaggerated and appear to change relatively quickly compared to those further from the terminator.

In addition, the apparent motion of the terminator is different, depending on where it is on the Moon's globe. Movement is maximised when the terminator is near the first or last quarter phases and fastest near the centre of the Moon's disc. This isn't to say the movement can't be seen or recorded away from these phases or positions, but rather that the changing shadow effects are greatest at these times and locations.

The best recording strategy is to pick a feature with good relief elements, mountains or deep craters being obvious candidates. Plan so you will be able to see the Moon for a period of a few hours, preferably with it located at a reasonable altitude. As well as position planning, take into consideration the local weather forecast. Although cloud cover can be unpredictable, choosing a time which is forecast to be clear will be better than choosing a time when a weather system is about to cross the sky!



Lunar mountain shadows make excellent subjects for timelapse studies

Centre your chosen feature and make an observation of it. This could be a sketch or image, concentrating on the position of existing shadows or small patches of sunlight visible in dark shadowed areas. Then wait, say, 30 minutes and do a similar observation. Repeat for as long as possible.

Comparing your results will show just how fast shadows on the lunar surface can appear to move. It's also a fascinating way to perceive the 3D nature of the lunar surface, the movement of the shadows giving relief features a more pronounced feeling of depth. If you have success, consider trying again with other features and create a library of lunar shadow movements.

DEEP-SKY TOUR

This month we take in the sights around the constellation of Sagitta, the Arrow

1 M71

Sagitta, the Arrow does look like an arrow with an isosceles triangle forming the flight and the shaft represented by the line from Delta (δ) to Gamma (γ). Globular cluster Messier 71 sits south of the mid-point.

M71 is an eighth-magnitude object. At powers of 200x, a 150mm instrument resolves some of M71's stars, a trend which increases with aperture. Curiously it looks more like an open cluster and was originally considered to be one. It lacks the core concentration of a globular and its stars have more elements heavier than helium than a typical globular. It also lacks the RR Lyrae-class variable stars normally found in ancient globulars. ☐ **SEEN IT**

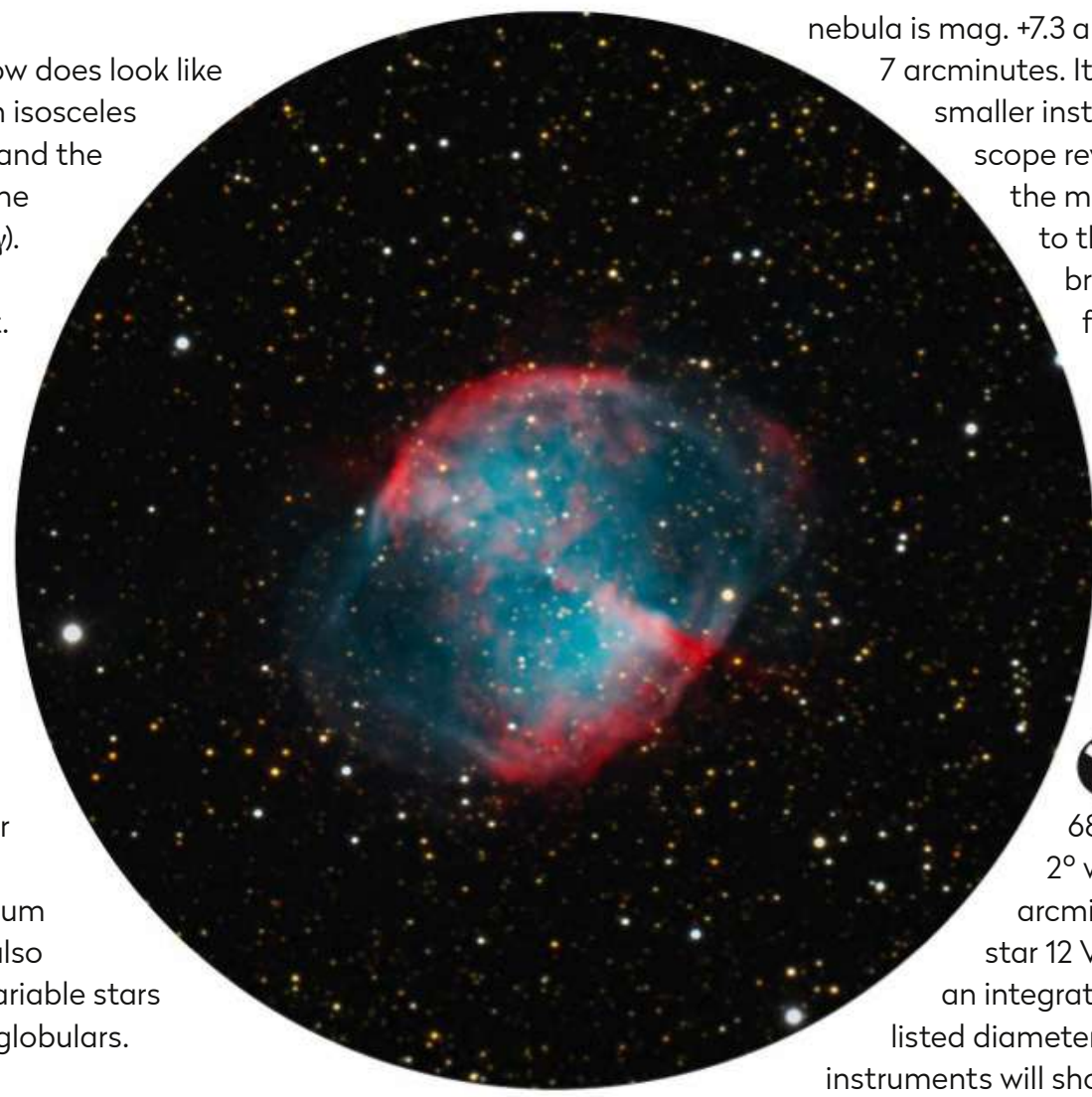
2 NGC 6886

Our next target is the tiny and relatively dim planetary nebula NGC 6886. Locate it by extending the shaft of the arrow by the same length again, away from the flight. NGC 6886 sits 0.4° southeast of the position you arrive at.

Apertures below 300mm will show the planetary as little more than a star-like point; high power over 400x is required to see anything more. The nebula consists of a bright inner shell with a faint, irregular outer shell. Although the outer shell is about six arcseconds across, amateur telescopes will only reveal the tiny two-arcsecond inner shell. Located 15,000 lightyears from Earth, this is believed to be a young nebula, the shell of material ejected from its star expanding for approximately 1,500 years. ☐ **SEEN IT**

3 M27

At the opposite end of the scale to NGC 6886 sits M27, the Dumbbell Nebula, in Vulpecula. Locate it by rotating Sagitta's shaft line 120° anticlockwise about Gamma (γ) Sagittae. Where Delta would end up marks the location of M27. The nebula is mag. +7.3 and large at around 7 arcminutes. It's easily visible through smaller instruments and a 150mm scope reveals irregular brightness in the main disc, with dark patches to the east and west, the two brighter lobes giving M27 its familiar name. The southern lobe appears brightest, showing knots on its edge through larger scopes. The central star is fairly straightforward to see at mag. +13.8. ☐ **SEEN IT**



FRANZ KLAUSER/MANFREDS WASSHUBER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

▲ **This is M27, sometimes called the Apple Core Nebula, but more commonly the Dumbbell**

4 NGC 6830

Next up is the open cluster NGC 6830, which can be found 2° west of M27 and 27 arcminutes north of mag. +4.9 star 12 Vulpeculae. The cluster has an integrated magnitude of +7.9 and a listed diameter of 10 arcminutes. Smaller instruments will show it as a small fuzzy patch roughly half this size, but a 250mm scope brings this straggly cluster to its full 10-arcminute diameter and reveals there to be around 30 members. The brightest individual star in the cluster's core is mag. +9.9. ☐ **SEEN IT**

5 NGC 6823

Locate NGC 6823, another open cluster, by extending the line from M27 through NGC 6830 for just shy of the same distance again. The cluster sits inside a faint but photographically very beautiful diffuse nebula, NGC 6820. This can be seen through amateur scopes but it's a challenge and requires the use of contrast-enhancing filters for the best view. NGC 6823 is prominent because of a tight diamond arrangement of stars, roughly one-third of an arcminute in length, at its centre. The brightest star in the diamond is mag. +9.2, with the entire cluster having an integrated magnitude of +7.1. A 150mm scope shows about a dozen stars, a 250mm instrument trebling this value. ☐ **SEEN IT**

6 Collinder 399

An asterism rather than a true cluster, Collinder 399 also goes under the name of Brocchi's Cluster or, due to its outline, the Coathanger Cluster. It's beautiful to view though a telescope at low power, as the extra light-gathering ability helps bring out star colours. The cluster measures 1.5° in length, and is found 4° northwest of Sagitta's flight. ☐ **SEEN IT**

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

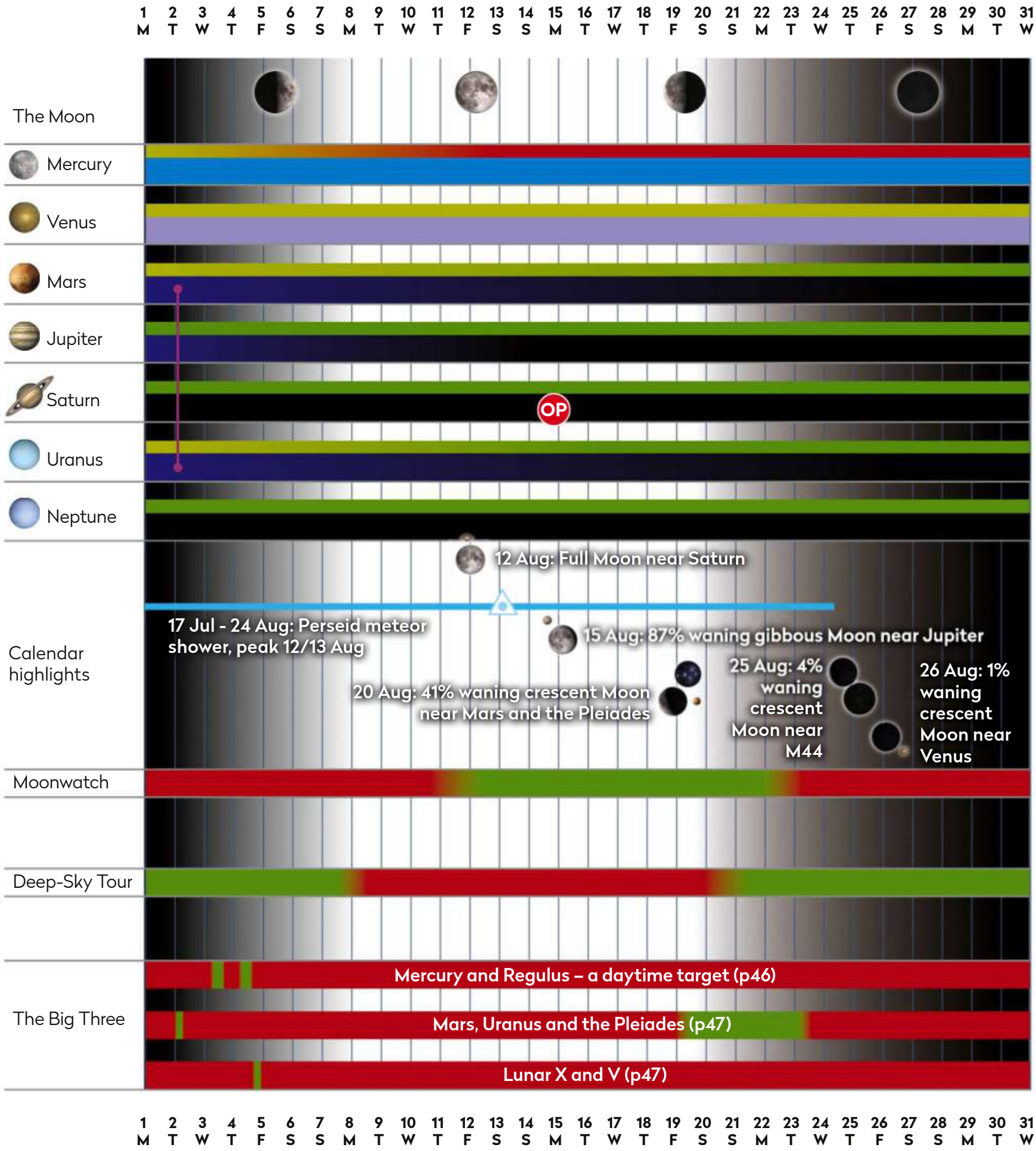
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

16
+25°
10
19h30m
22
17
20h00m
13
+25°
Anser
α
14
4
NGC 6830
5
VULPECULA
M27
NGC 6823
NGC 6820
3
12
Abell 68
2°
N
1°
E
W
+20°
2
NGC 6886
S
η
Collinder 399
6
γ
NGC 6802
ζ
Minkowski 1-71
9
M71
SAGITTA
5
1
Harvard 20
4
δ
Kohoutek 3-51
NGC 6879
13Z
α
11
β
10
20h00m
19h30m

AT A GLANCE

How the Sky Guide events will appear in August


1 M 2 T 3 W 4 T 5 F 6 S 7 S 8 M 9 T 10 W 11 T 12 F 13 S 14 S 15 M 16 T 17 W 18 T 19 F 20 S 21 S 22 M 23 T 24 W 25 T 26 F 27 S 28 S 29 M 30 T 31 W
The Moon
Mercury
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
OP
Calendar highlights
12 Aug: Full Moon near Saturn
17 Jul - 24 Aug: Perseid meteor shower, peak 12/13 Aug
15 Aug: 87% waning gibbous Moon near Jupiter
20 Aug: 41% waning crescent Moon near Mars and the Pleiades
25 Aug: 4% waning crescent Moon near M44
26 Aug: 1% waning crescent Moon near Venus
Moonwatch
Deep-Sky Tour
The Big Three
Mercury and Regulus – a daytime target (p46)
Mars, Uranus and the Pleiades (p47)
Lunar X and V (p47)

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

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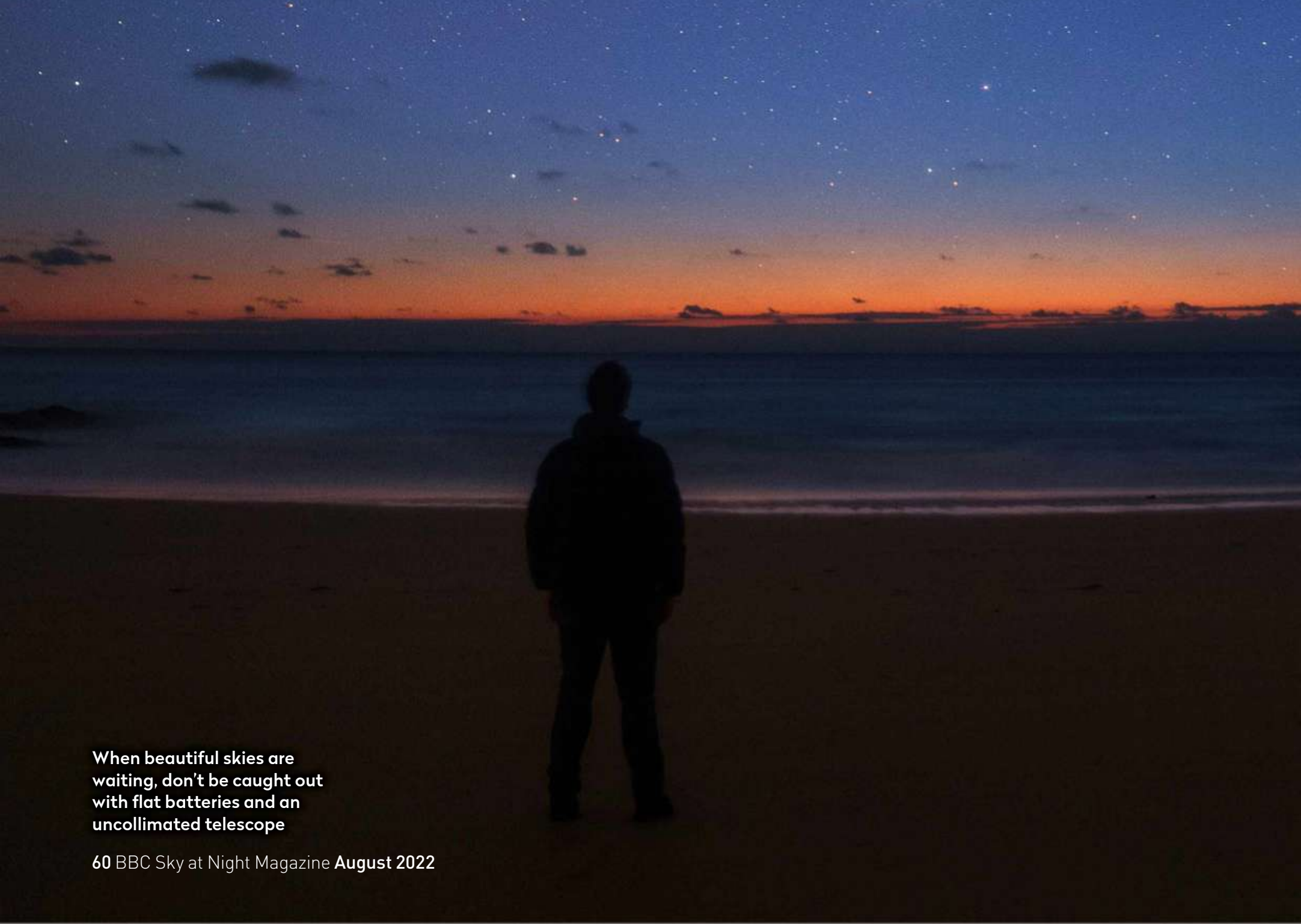
12 ASTROPHOTOGRAPHY PITFALLS (and how to avoid them)

Expert astrophotographer **Will Gater** runs through the common mistakes even experienced photographers make and how to ensure your next imaging session is free of them



When beautiful skies are waiting, don't be caught out with flat batteries and an uncollimated telescope

Starting out in astrophotography is an exciting, but often bewildering, experience. When you think about it, it's probably one of the strangest types of photography out there. You're going out, in the dark, at night – sometimes in remote spots – trying to capture a picture of something that's not only really distant but extraordinarily faint by any normal photographic standard.

Oh and, by the way, not only will the entire sky be moving while you're doing this, but the atmosphere you're shooting through will be wobbling too. And that's before you've even considered the prospect of actually processing the data you've captured.

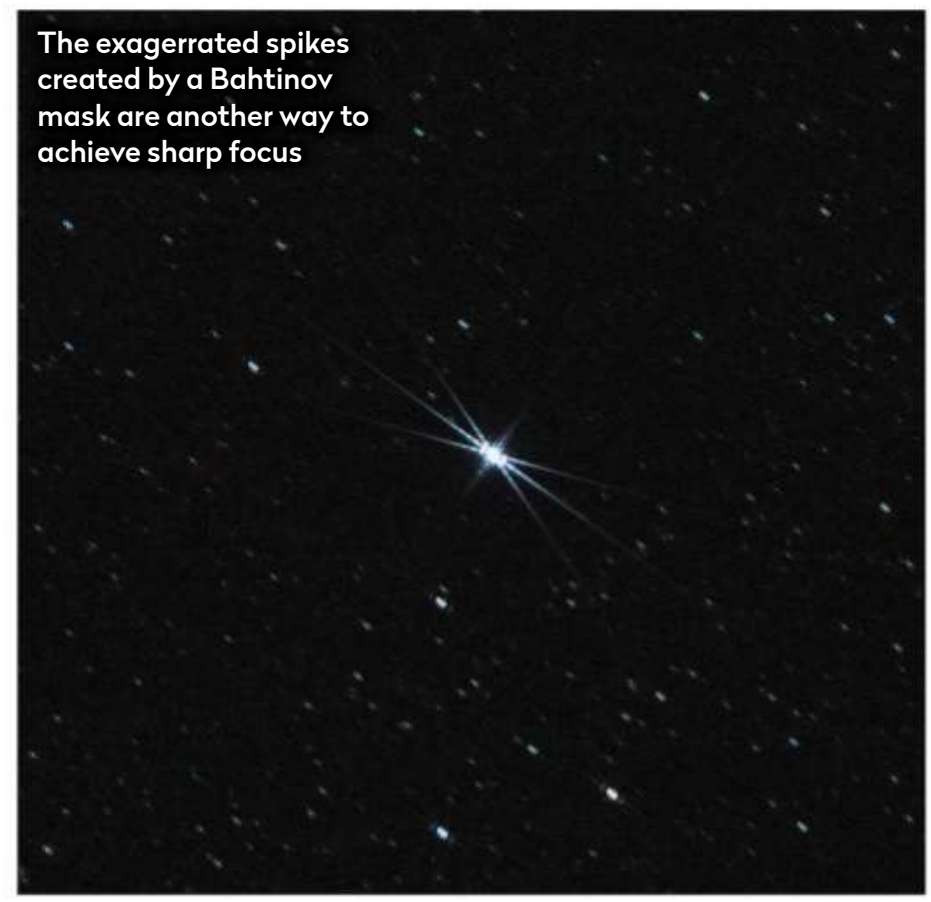
It's no wonder there are so many slip-ups that it's easy to make. In this piece I'm going to look at 12 common imaging mistakes and how you can avoid making them. I've made every single one of them myself at one point or another, and I'm sure in time you'll find new and interesting ones of your own too – the astrophotography learning process is one that never ends!

Will Gater is an astronomy journalist and science presenter. His latest book, *The Mysteries of the Universe*, is published by DK

1. Not getting the focus right and capturing soft data

As imagers we often dedicate tens of hours, if not more, to setting up a scope and mount, getting the auto-guiding or tracking just right and then carefully processing the data we capture. But the quality of the final image all hinges on a pivotal process that can all too easily be rushed: getting the optics *perfectly* focused. If you're not using a focusing aid – such as a Bahtinov mask – time spent carefully confirming focus will never be wasted. When doing this, try to slowly adjust the focuser a little way past what you think is the focus point, and then gradually return back through to the other 'side' of that point until you're absolutely sure where it is.

If you're using a live preview screen on a camera, check focus on several medium-bright stars in the frame, as sometimes it's not easy to accurately judge when a bright star is at its smallest and, therefore, sharpest. And once you're focused, continue to check that the optics you're using *remain* in focus throughout your imaging session. Did you very slightly nudge the focus ring on the lens as you manoeuvred the camera around, for example? Has the focus of your imaging system changed minutely as the air temperature has varied? Did a filter change alter the focus point? Athough they can be time-consuming, all of these little checks, will ensure the data you capture is the clearest and crispest it can be.



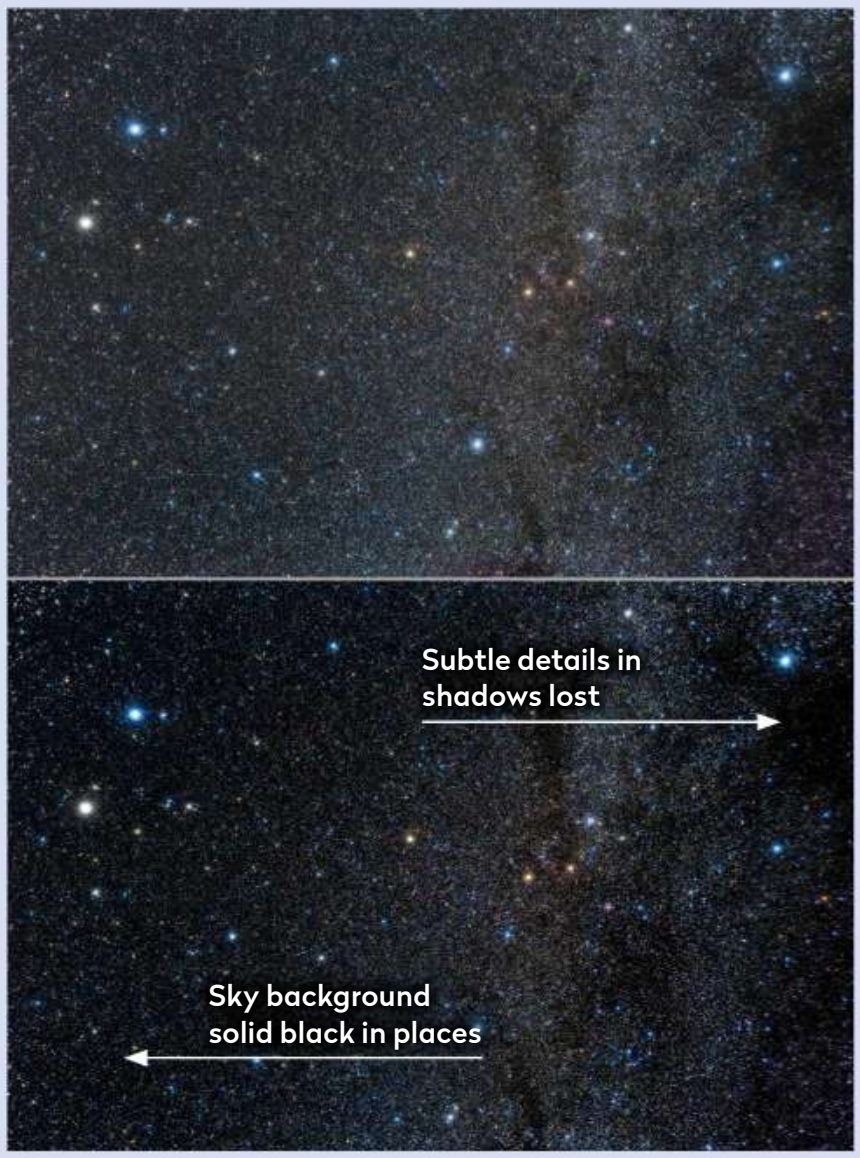
The exagerrated spikes created by a Bahtinov mask are another way to achieve sharp focus

Your scope needs time to adjust to outside temperatures

2. Not letting optics cool

With clear skies a rarity in the UK, it's understandable you'd want to start imaging as soon as you've got your kit outside. However, it's essential to allow a telescope's optics to cool down to close to the ambient air temperature before you do, particularly in the case of high-resolution lunar and planetary imaging. This is because air currents inside a warm telescope can degrade any data you capture, making the final image softer. If it is safe to and there's no risk of inclement weather (and there's a clear night ahead), put the covered telescope outdoors in advance of your imaging session and you'll get better results. ▸

ALL PICTURES: WILL GATER



▲ The same data, processed differently. In the bottom image the black point has been 'clipped' causing a loss of detail

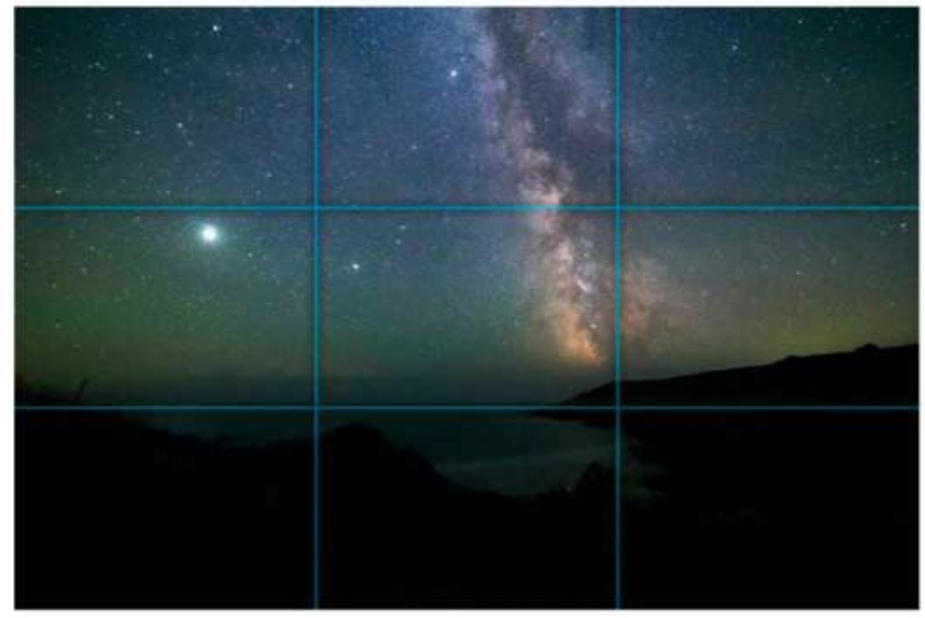
3. Clipping the black point in post-processing

Here we come to our first 'mistake' which is concerned with something a little more aesthetic than practical, and it centres on how we wish to represent space in our images. When it comes to the depictions of areas around celestial targets, or the night sky more generally, I'm of the view that – in most kinds of astrophoto – space, and the night sky, should never be *completely* black. The sky, the Galaxy and beyond is full of the diffuse light of stars and other sources, and so to make the background of an astro image a solid black doesn't seem quite right.

Now you may disagree on aesthetic or artistic grounds, in which case I very much respect your choice, but if you've never considered this before, check that you're not inadvertently 'clipping' the black point. This is where the contrast of an astrophoto is tweaked to a stage where, when you inspect the 'levels' tool of an image editor like Photoshop or GIMP, the so-called 'black point' arrow slider cuts off the left edge of the levels histogram. This results in subtle, darker shades in the picture being lost and appearing simply as solid black. This is something to watch out for in deep-sky and nightscape imaging in particular, as it can lead to a loss of detail in shadowy features like dark nebulae.

4. Not planning your composition

Composition is one of the easiest things to overlook in imaging, yet it has a huge effect on the impact of an astrophoto. If you're setting up a shot, spend some time thinking about how you'll draw the viewer's eye into the picture and how the object or scene you're shooting is placed in the frame. For nightscape-style work, with a horizon and foreground, it can be useful to think about the 'rule of thirds' principle, where you arrange features or landmarks into three zones, with key features that you want to highlight placed close to the points where a set of lines cross near the centre of the shot (see below). For deep-sky imaging, offsetting an object from the centre of the frame will often create a more engaging composition than simply placing it right in the middle.



▲ Imagine the scene divided up as above and position your key elements at or near the lines and intersections of the grid

5. Using poorly collimated optics

▲ Targets won't appear sharp if your mirrors are out of alignment

If you're imaging with a reflecting telescope, it's really important to regularly check the collimation – or alignment – of its optics if you want to take the best images you can. This is especially important when carrying out long focal-length, high frame-rate imaging of the Moon and planets. There are numerous online collimation guides for a variety of different telescope designs, and experienced members of your local astronomical society may also be able to offer advice if you get stuck.

WILL GATER X 5, STEVE MARSH

6. Over-sharpening your data

When you've spent so much time collecting precious imaging data it's tempting to push it as hard as you can in the later post-processing stages: you naturally want to see if you can get as much detail as possible out, but it's remarkably easy to sometimes take it a step too far. Often you might not even notice what's happened in that moment when you're sitting at your computer, deep in thought about the processing. I know I've certainly done it with my own pictures, and it's only when I've posted the image online, or seen it on my website, that I think, "Hang on, that's a bit overdone".

Although one can push data too far in any field of astrophotography, I find it's particularly easy to do in areas where we're dealing with data that, from the beginning, has to be refined and sharpened to make fine details visible, like high-frame-rate 'lucky' imaging of the Moon and planets. Here – when you're wavelet sharpening or applying an 'unsharp mask' later in an image editor – nudging the sliders a little too much can quickly result in sharpening artefacts, like dark borders around features or a general 'crunchy' look.

To be vigilant, I find it's good to make adjustments incrementally, going back and forth to check each step, and then leave the image for a while. When you come back to it with fresh eyes and compare it to earlier iterations, you'll see if you've really made the enhancements you want.

▲ It's all too easy to over-sharpen objects like lunar craters. Avoid that harsh and 'crunchy' look (right) by making adjustments incrementally and taking breaks from your processing

7. Not recceing a site before visiting at night

If you're planning on travelling to a new dark-sky spot or one you haven't visited for a while, recce the site beforehand in daylight. Not only should this help you identify safety issues and avoid hazards, but if you're a nightscape imager it'll also give you a chance to scout out compositions. ►

Check out your imaging site before nightfall for potential hazards

Shooting in RAW captures far more data, which you can then reprocess time and again

8. Not shooting in RAW with your DSLR

One of my biggest regrets from my early days of digital astrophotography was not shooting in RAW format when using my first DSLR. While I can go back to the vast majority of the DSLR images in my archives and process the RAW files from scratch again – with the benefit of experience and new processing software or techniques – the images from those early years are just standard JPEG files, which by their nature are compressed. The RAW format files preserve much more data, so it's similar to having a digital negative, while if you try to process an old JPEG you're essentially working with an inferior copy of the full data captured by the camera. Even if you don't have the software or intention to process RAW files now, I'd still recommend shooting in RAW, as years down the line you may wish to revisit the data to see what's lurking in it.

9. Not gathering calibration files

In a similar vein to neglecting to shoot in RAW, is the issue of capturing calibration files. This is mainly applicable to deep-sky imaging with a telescope or long lens, and it's one of those occasions when a little effort can have a big effect on an image. In basic terms there are two kinds of calibration files that are worth capturing as a beginner: 'flats' and 'dark frames'.

Flats, or flat fields, are images used to capture the optical defects in the imaging system, such as dust shadows on the camera sensor and vignetting (the darkening in the periphery of a frame caused by the optical housing of the telescope). Flats can be captured using a clean, white cloth or pillowcase carefully placed over the front aperture of your telescope; you then shine a torch onto the cloth and take a well-exposed image.

▲ **Taking flat-field frames lets you remove defects such as vignetting and dust shadows**

Dark frames are exposures taken under the same settings and conditions as regular sub-exposures, except the lens cap or telescope aperture is covered so as to only record the camera noise. In both cases these frames are then subtracted by software when it comes to processing the data, and the calibration they provide will substantially improve the quality of even a basic deep-sky photo.

ALL PICTURES: WILL GATER

Flat batteries, full SD cards and missing kit can all ruin your imaging trip

10. Not preparing contingency kit

There's nothing that ruins a night of astrophotography like turning up to an observing site with a camera that doesn't have a memory card in it or that has a flat set of batteries. My greatest triumph in this area was driving over an hour to a dark-sky spot with my entire imaging rig except the small – but *absolutely vital* – baseplate that holds the DSLR to the tripod head. It's so easily done. Alarm reminders on my phone throughout the 24 hours before an imaging trip are one way I now build in contingencies to avoid these things happening, as they're harder to forget or overlook than a physical checklist.

11. Forgetting dew protection

If the atmospheric conditions are right, dew forming on the exposed surfaces of camera lenses and other optics can stop an imaging session in its tracks, sometimes over the course of taking just a few sub-exposures. If you've spent a long time setting up or waiting for skies to clear, this can be really demoralising, so it's good to be vigilant. What's more, on some nights even dew shields won't be enough to stop moisture from forming on a telescope or camera lens. There are many active dew prevention systems on the market. These typically work by wrapping around the telescope tube or lens and giving off a very gentle heat, which inhibits the formation of dew on the optics. It's worthwhile investigating even a basic system, as it should give you several happy hours of dew-free data capture.

A lens warmer will keep dew at bay and stop your lens from fogging up

12. Applying excessive noise reduction

I'll caveat this last point by saying that there's no 'right' answer and what follows is my opinion, but it is something that beginner imagers are perhaps being too hard on themselves about, thinking they need to make their data look 'perfect'. When I look at astrophotos online I often see some that have had very strong noise reduction filters applied, giving the shot a really smoothed look. Personally, I'm not bothered by a little noise in an image and I'd much prefer it over a highly smoothed background – in some ways the noise is part of the 'story' of the shot. So if you're tempted to massively crank up the noise reduction filter, maybe, instead, think about what leaving some of it in will bring to the picture.

► **This image of the Lagoon Nebula shows how very strong noise reduction (left-hand side) can make for overly smoothed results**

An astronomer at the BOTTOM OF THE WORLD

Georgina Dransfield has just returned from months at the South Pole, working to expand our understanding of exoplanets – and dreaming of a pair of jeans

GEORGINA DRANSFIELD X 2

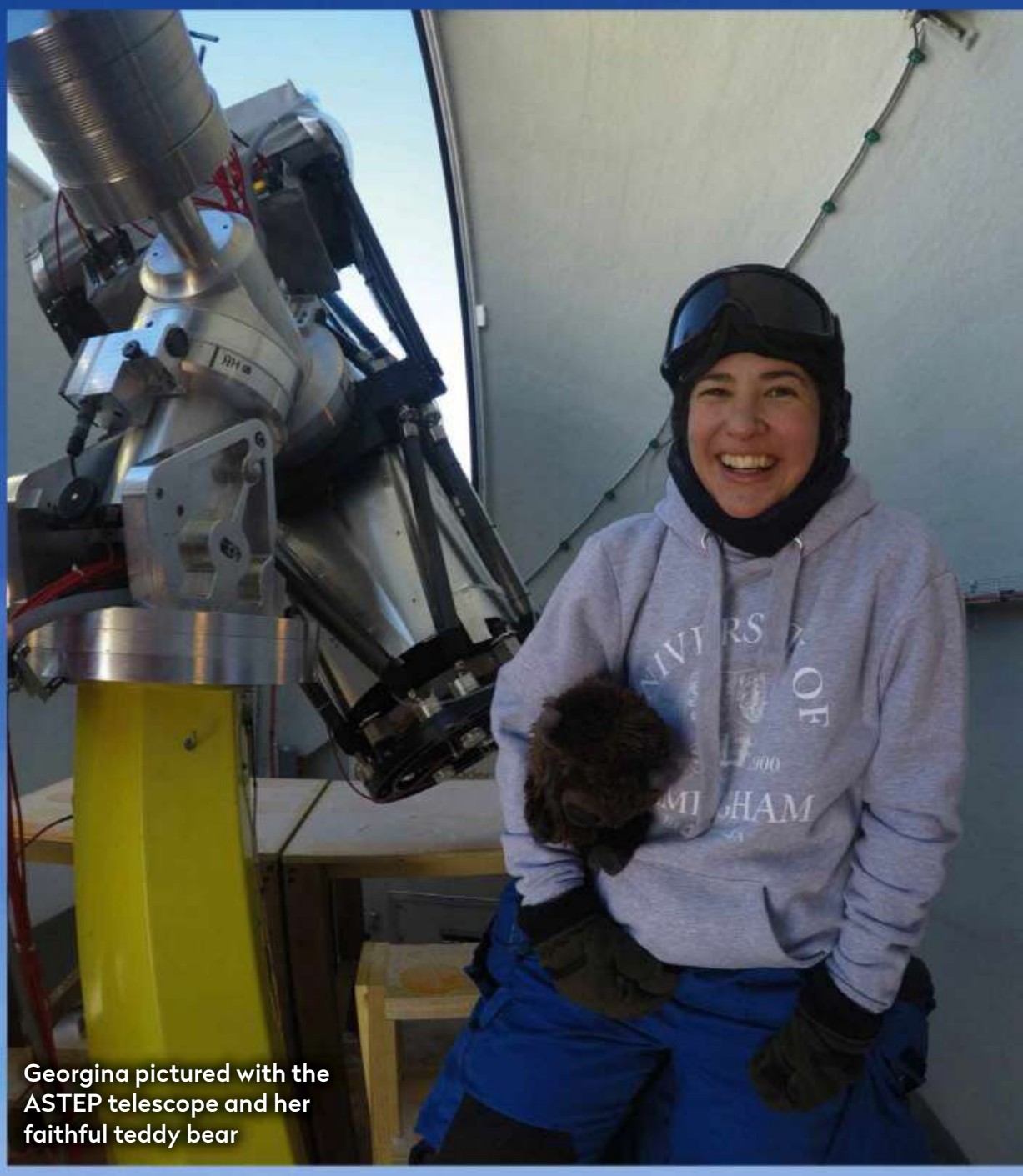
Miles of snow and ice and round the clock daylight greeted the author in Antarctica

There's genuinely not a lot I'd change if I could do my mission to Antarctica again. The science I went there to do went as well as I hoped it would and I made it back without losing any body parts to frostbite. The only real regret I have is that I didn't pack a pair of jeans; somehow this most inane of oversights managed to cause me a not-insignificant amount of frustration that only grew as the weeks ticked on by.

I began my jeans-less journey in Great Malvern, Worcestershire on 17 November 2021. Four trains, five planes, two quarantines and 31 days later I arrived at Concordia Station on Dome C in Antarctica, where I would be working for the next seven weeks as part of the Antarctic Search for Transiting Exoplanets (aka ASTEP) telescope summer team.

Goodbye to sunsets

The group I travelled with, mostly glaciologists and seismologists, were all itching to get to Concordia to begin data collection, and they were understandably curious as to why astronomers were headed there during the months of never-ending daylight. It's a fair point. Antarctica is a brilliant astronomical site because of the long nights and dry air, but we only get to observe for half the year. So, why bother going in the summer when it never gets dark? Simple: for ASTEP, our annual summer campaigns represent our only opportunity to access the telescope for maintenance and upgrades. ▸

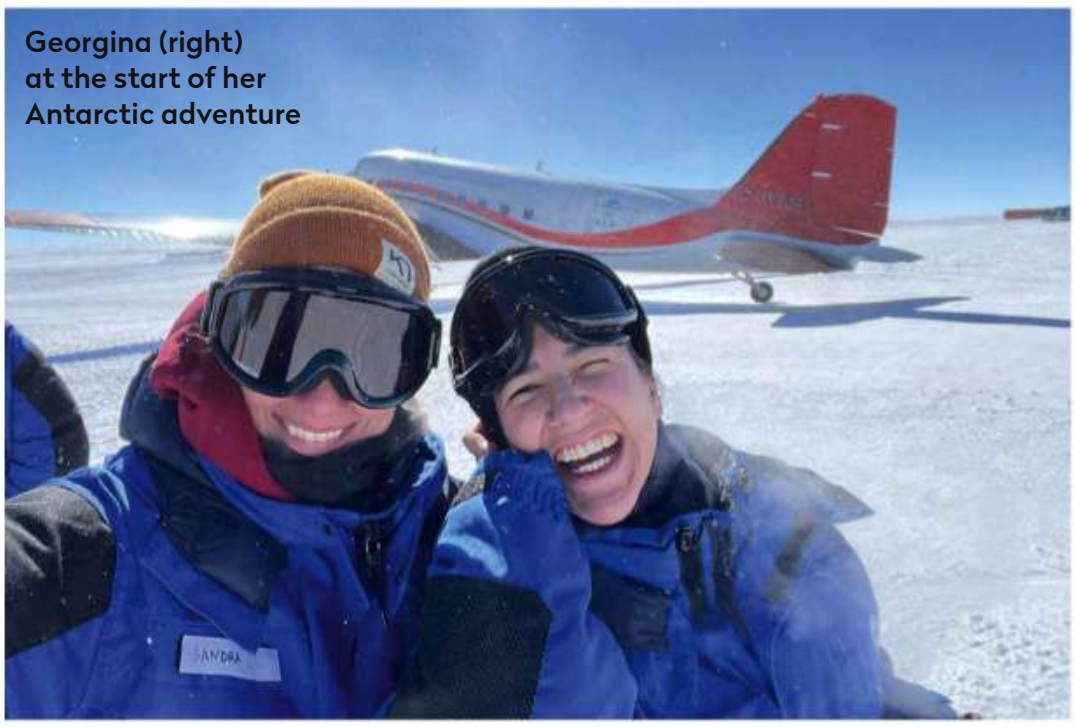


Georgina pictured with the ASTEP telescope and her faithful teddy bear

▲ ► **Concordia research station is surrounded by 1,000km of snow in all directions. It's so cold outside that your face can freeze instantly, as this picture (right) of ESA's Dr Carmen Possnig shows**

► As I climbed out of the propeller plane outside Concordia, I realised that all cold I'd experienced leading up to this point was just pretend cold. This was real, proper, freeze-the-insides-of-your-nose-in-a-millisecond cold. I really wanted to take photos, but I also wanted skin, so I prioritised the latter and ran inside, where I was greeted by my colleagues. Two of our team, Karim and Djamel, had already been there for a couple of weeks dismantling the telescope to move it to its new dome. My arrival with the fourth member of the gang, Olivier, completed the group so we could start work in earnest.

Unlike me, my colleagues were there to do some high-level work with the telescope itself. Karim, Djamel and Olivier were jointly responsible for two



Georgina (right) at the start of her Antarctic adventure

Packing for one of the coldest places on Earth (and not a pair of jeans in sight)

ESA/IPEV/PNRA–E. KAIMAKAMIS, ESA/IPEV/PNRA-M. BUTTU, GEORGINA DRANSFIELD X 3, NASA

How do we know where to look?

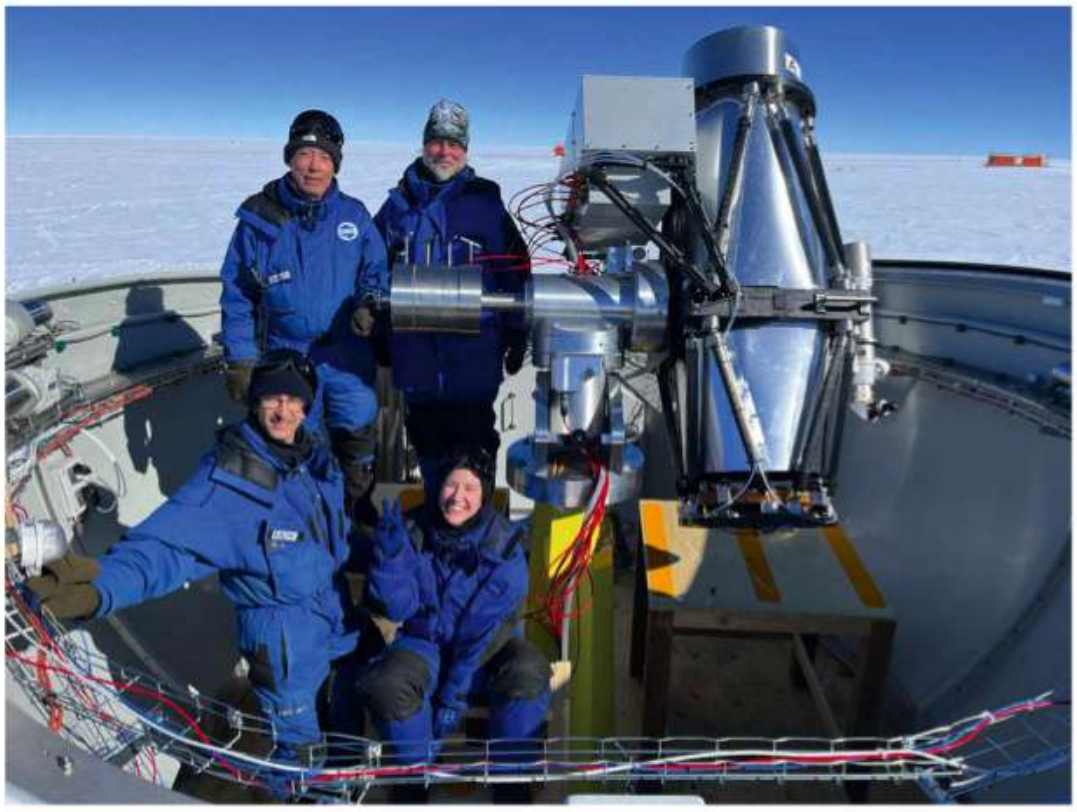
The telescope's location gives it a unique view of the night sky

ILLUSTRATION

ASTEP follows up exoplanet-hunter TESS to sift the true planets from the imposters

ASTEP was originally conceived as a survey in its own right, intended as a ground-based successor to the French satellite CoRoT (Convection, Rotation and planetary Transits), but nowadays our time is mostly dedicated to TESS follow-up. TESS is the Transiting Exoplanet Survey Satellite, a space telescope searching the sky for exoplanet candidates. Unlike Kepler, which stared continuously at the same patch of sky, TESS covers the whole sky in 26 sections. Its observations are sent to the ground where they're made into light curves to identify potential candidates. So where does ASTEP come into this? Well, TESS can't distinguish between true planets and false positives, so a global network of observatories on the ground reobserves TESS's candidates and either validates them or rules them out. ASTEP's unique location close to the Pole allows us to go after a specific subset of TESS's discoveries, which are largely inaccessible to everyone else: long, infrequent transits, as the polar region has the largest amount of overlap between the individual sections of TESS's coverage and is observed the longest. With the average night on Earth lasting about 10 hours, and our longest going on for a couple of months, those super-long events really are best left to us.

▸ Turn to page 35 to read more about the candidate planet TESS has discovered.



▲ Georgina (bottom right) with members of her team inside the ASTEP dome

ASTEP is a 40cm telescope dedicated to the search for planets outside the Solar System. While there are several ways to find new worlds, we use the approach that's led to over 75 per cent of confirmed exoplanets: the transit method. A transit is an astronomical event where a planet passes in front of its parent star causing a characteristic dip in brightness as it temporarily obscures a tiny portion of the stellar disc. We know if we've observed a transit by plotting a graph of stellar brightness over time for the target star, called a light curve. If we see a V- or U-shaped dip in the light curve, then we might be onto something.

So here comes the fun bit: the depth of this dip tells us something about the size of the planet relative to the host star's size. *If* it's a planet. That there 'if' is the bane of planet hunters' lives. Instead of a planet, the dip in the light curve could be caused by an astrophysical false positive like, say, an eclipsing binary. Those pesky double stars have light curves that mimic transit light curves, causing many a broken heart in the world of exoplanet science.

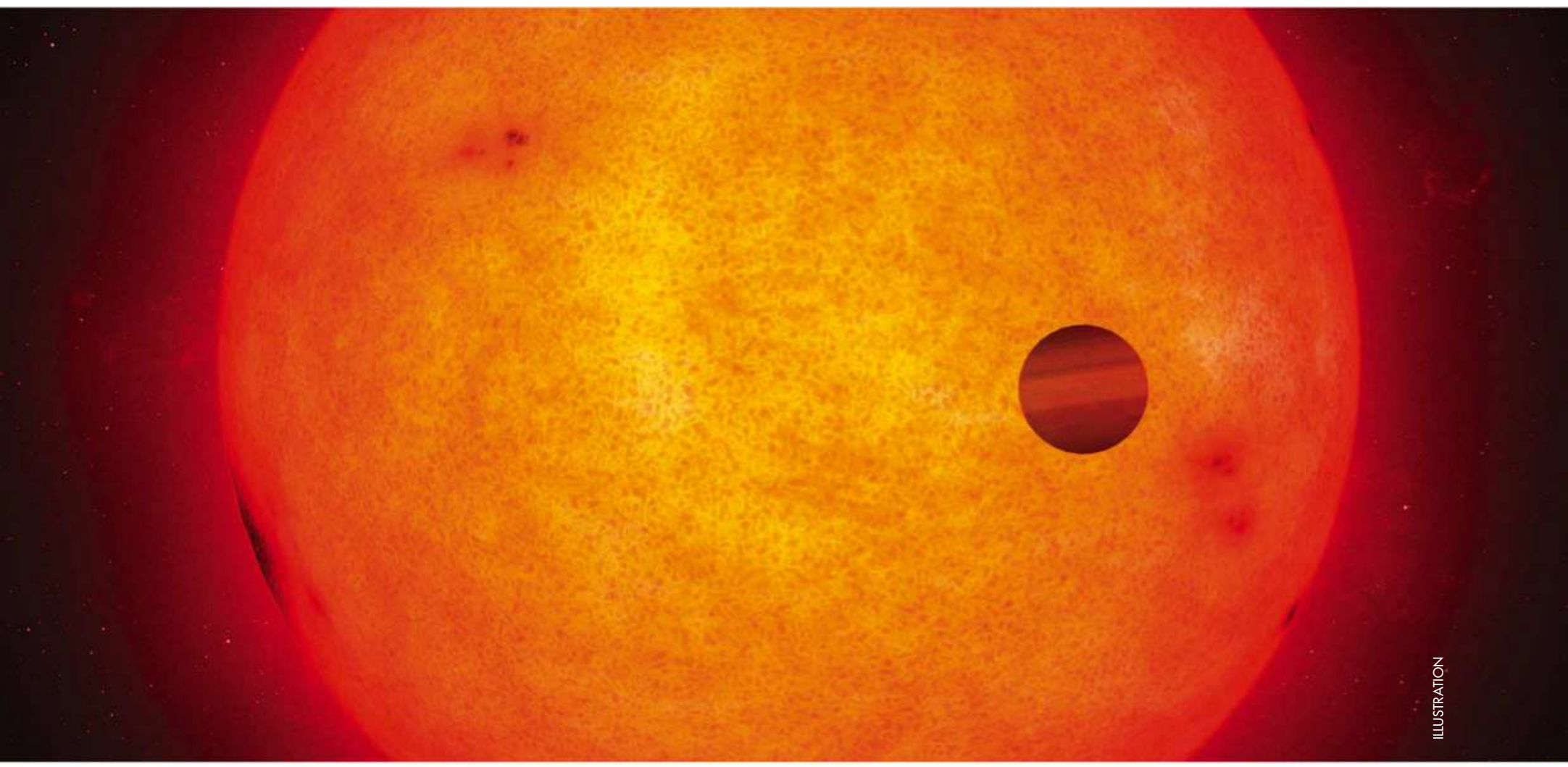
Fortunately for us, we have a weapon in our fight against these lookalikes. In an exoplanet's transit light curve the depth should be the same when observed in different colours, while the curve from a binary eclipse could vary significantly with wavelength. This means that by observing simultaneously in two colours, we can detect a transit *and* rule out the most common false-positive scenario.

The work my colleagues did required them to put on their full polar gear and walk the 500m from the base to the telescope and its nearby astro-shelter every day. Repeatedly. I *could* do that, and I certainly *did* do that for the first few days. But, you see, I didn't want to. Having to spend 15 minutes putting on a ton of layers and then trudging half a kilometre ▸

of the three missions that made up our summer campaign: installation of a new two-colour camera box and relocation of the telescope to a bigger, better dome. The new dome can be opened and closed remotely from Europe, meaning that we would no longer have to leave the telescope open all season. Or worse, send the winterover astronomer out to close the dome manually when the weather inevitably deteriorates.

Lights, camera, action

The two-colour camera box is also a significant upgrade for ASTEP. In simple terms, it contains two cameras: one detects mostly blue light, while the other is sensitive in the red. To understand why this will allow us to do more and better science, we need to first consider what ASTEP is designed to do.



ILLUSTRATION

▲ **An exoplanet transitting its parent star leaves a different wavelength signature than an eclipsing binary**

▸ in the world's softest, driest, most powdery snow while wearing boots that, while very warm, weighed a couple of kilograms each... that novelty wore off rapidly. Also, I didn't *have* to do it because my job, mission number three, was the installation of our new automatic data analysis pipeline and for that I just needed to be on the same network as the telescope computer, which I could achieve on the main base.

I realise it might be hard for some readers to really get excited about a quest to the ends of the Earth to install software on a computer, but let me tell you now that the pipeline is a thing of beauty.

ASTEP's two cameras photograph the chunk of sky we tell it to look at and the CCDs have several million pixels each. These pixels get exposed for however long we decide, then the image is saved and we begin another one. This continues for the duration of the observation, which can be anything from a few hours to a handful of days. The job of my pipeline is to get us from these digital photos of the sky, often thousands of them containing many hundreds of stars, to the light curve of just one star. But not just any star, it must be the *correct* star.

Below-zero bandwidth bothers

So the pipeline has to process the full set of images produced each night. From image calibration and star detection, to correct target identification and light-curve plotting, the pipeline is responsible for getting us the data products we need to discover and characterise new planets. Throughout our winter observing season, the pipeline must run automatically on-site, with just the results emailed to us daily. This is because we can't get our hands on the raw images until one of us goes there the following year and copies them onto a hard drive. It's just one of the many limitations of working in such an extreme environment: the internet is terrible, so we don't have the bandwidth to download our raw data as it's taken.

I'd spent the weeks and months prior to the trip developing the pipeline and practicing installation on various UNIX architectures, so that bit went smoothly and was completed within the first three days. I then spent the rest of my time at Concordia testing and

Thanks to the three-month-long nights, ASTEP specialises in tracing rare planets with long, infrequent transits

MARK GARLICK/ISTOCK/GETTY IMAGES, GEORGINA DRANSFIELD X 7

The restaurant at the end of the world

Finding a decent meal at the South Pole isn't easy, especially when you're a vegan

We all know the joke about how you know someone's vegan because they tell you, but the vegan food on base was genuinely comical. I did worry how a French–Italian station would handle feeding me, and while there were a few rather delicious hits, the misses were considerably more spectacular, the most astounding being my Christmas dinner: sliced orange, mountains of eggless mayonnaise, capers, green beans, diced tomatoes and… chips. But I did Britain proud (I think) by introducing the base to chip butties. I'm sorry to report they were met mostly with disgust. Not one to be put off by widespread disapproval, I made 'some form of potato sandwich' my default meal after a while. I was often saddened by the lack of vegan desserts, so I took matters into my own hands and made a couple of cakes. I also realised that I had everything necessary to make vegan pancakes, so midnight pancakes became a thing. Strictly speaking, I wasn't supposed to be in the kitchen at all, but as is so often the case, it pays to make friends with the chefs.

▲ From left: Christmas dinner left a lot to be desired and colleagues didn't appreciate chip butties, but homemade cakes saved the day

▲ Home comforts: Georgina and the jeans she borrowed from an IT technician on the base (left). Having arrived at the station not knowing anyone, she made some friends for life during her time at the South Pole (right)

Georgina Dransfield is an Anglo-Uruguayan teacher-turned-astro-PhD student at the University of Birmingham

debugging. A task that was huge, tedious and could have been comfortably done in jeans.

You see, the reason I didn't pack jeans was because I figured they wouldn't be practical or comfortable under my polar suit. As it happened, I wore it seldom, and instead sat around in glorified pyjamas most of the time. One of the hardest things about working in Concordia is how far removed everything is from normal life. Yes, I'm referring to the cold, but also living in such close quarters with a very small group of strangers. And the constant daylight messing with your sleep patterns. And having such limited contact with loved ones back home. Getting out of breath from climbing a single flight of stairs. The puzzling lack of Nicolas Cage movies. It's all hard and a bit alien, but it's made easier by having some familiar things. I did consider this ahead of time – I had a pack of Jammie Dodgers and my 30-year-old teddy bear, but not one single pair of jeans.

What really alleviated some of the hardships of being there for so long were the people I bonded with. When I'd arrived on 18 December, everyone at Concordia was a stranger to me. By Christmas I'd made friends and by New Year's Eve some of those friends felt like family. A couple of weeks into the new year, the IT technician very kindly loaned me a pair of jeans because I wouldn't stop berating myself for neglecting to pack some. So maybe, on reflection, it was a good thing since it gave us all something to laugh about: me in a Sicilian chap's tiny jeans. But next time, if there is a next time, I know what will be at the very top of my packing list.

The fundamentals of astronomy for beginners

EXPLAINER

Curiosity, 10 years exploring Mars

NASA's car-sized Red Planet rover has set new standards in planetary exploration

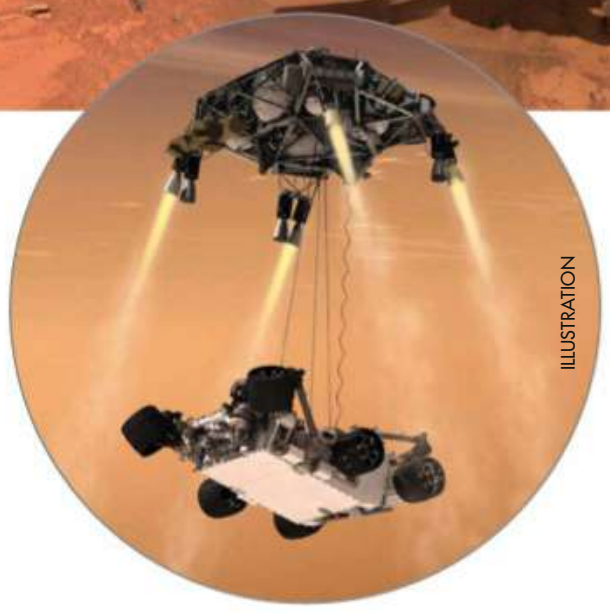
By combining several images taken by Curiosity's robot arm, NASA scientists are able to assemble a 'selfie' of the rover

NASA/JPL-CALTECH/MSSS X 2, NASA/JPL-CALTECH X 4, NASA/JPL-CALTECH/MSSS AND PSI

This August marks 10 years since Curiosity, one of the most advanced planetary rovers ever launched, landed on Mars. For a decade the car-sized wheeled robot has been studying the climate and geology of Mars in preparation for human exploration and helping to answer questions about Mars's past suitability for life.

But its launch was repeatedly pushed back as NASA faced many delays. Finally, on 26 November 2011, the mission clock began as an Atlas V launched the rover from Cape Canaveral Air Force Station.

The selection of Curiosity's destination on Mars had begun in June 2006, when an international group started to whittle down 100 potential landing sites to just one. By June 2011 the 154km-diameter Gale Crater had finally been chosen for its exposed layers of sediments, thought to be left by the water of an ancient lake.



ILLUSTRATION

▲ Seven minutes of terror. The Sky Crane lowers Curiosity to the Martian surface

Curiosity's landing eventually came on 6 August 2012, and was aimed at the tightest landing ellipse of any mission to date. The Spirit and Opportunity rovers' landings had been within a predicted area of 150 x 20km in 2004; Curiosity was to narrow that down to just 7 x 20km. To achieve this, the craft had to slow down by a factor of around 10,000, from a relative approach velocity of 21,000km/h to a slow walking pace of just 0.75m/sec at touchdown – no easy feat for a rover 3m long by 2.8m wide, with a mass of almost 900kg. Curiosity's mission planners took a novel approach to landing, describing it as either 'the least crazy' solution or the 'seven minutes of terror'.

Feeling supersonic

This began when the sparse Martian atmosphere started to brake the craft at an altitude of approximately 125km, then at 11km a supersonic parachute deployed, reducing the speed of descent to 322km/h. So far so good, but next came the novel approach: an autonomous, eight-rocket Sky Crane was to hover 35m above the surface and gently lower

Perseverance & Ingenuity

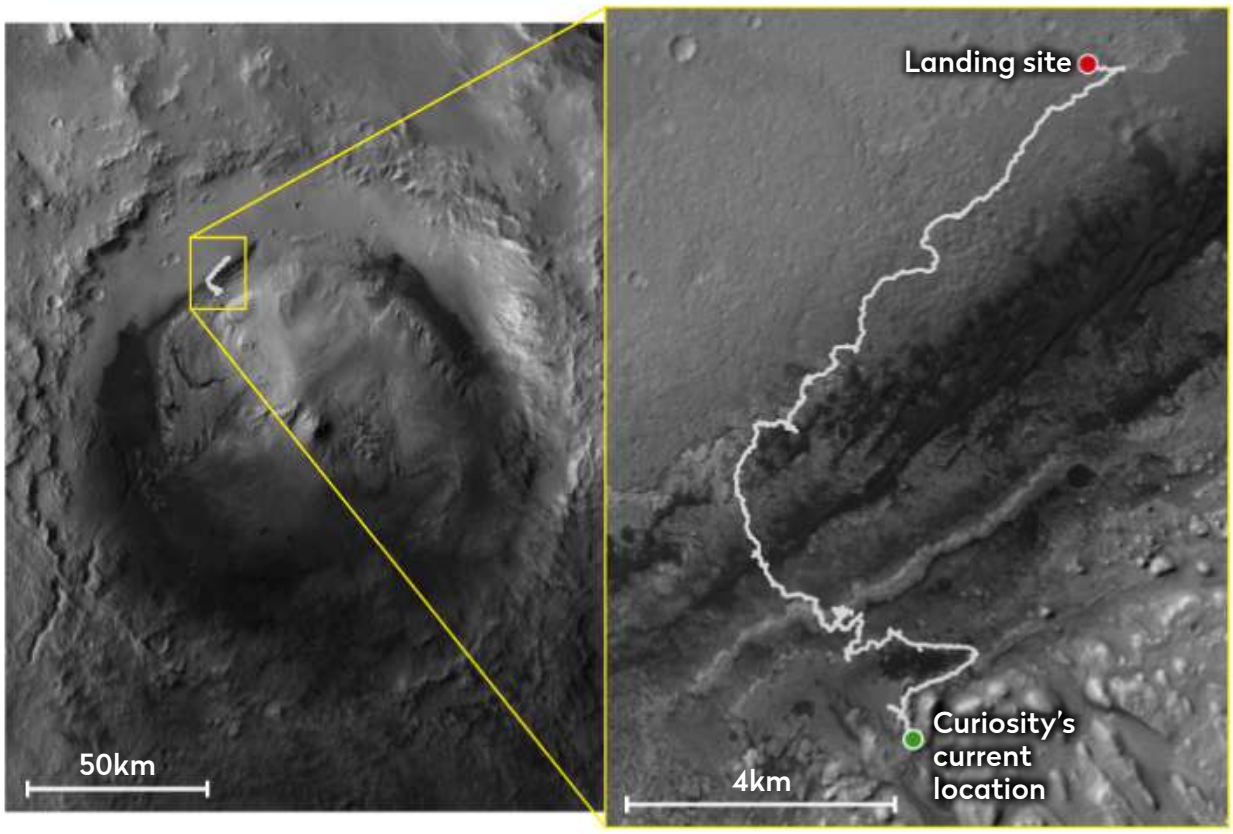
Curiosity is not alone on the windswept Martian surface

Ingenuity, pictured on the Martian surface by Perseverance prior to lift-off

So successful is Curiosity's design that it was used as the basis of a later NASA Mars rover, Perseverance. Also exploring Mars looking for evidence of past life, Perseverance carries upgraded instruments and is collecting samples, leaving them cached in tubes ready for collection by a future sample-return mission.

Launched on 30 July 2020 and landing on 18 February 2021, the mission used the same Sky Crane landing profile as Curiosity. The rover is a little more massive than its predecessor, weighing in at 1,025kg on Earth (which is reduced by around a third in Mars's gravity), but has similar dimensions of 3m long and 2.75m wide.

Perseverance also carried another craft, the Ingenuity helicopter. When it rose vertically from the surface and hovered for 39 seconds on 19 April 2021, it made history by being the first powered flight on another planet. It was hoped Ingenuity would provide data from five test flights, but as of April 2022 it has completed 28 flights, covered 6.9km, and spent over 54 minutes in the air, reaching altitudes of 12m and speeds up to 20km/h.



▲ Curiosity's route in Gale Crater. The rover has so far covered 28km at a sedate 4cm/sec

Curiosity on three nylon cables. The concept worked perfectly and the cables released so the Sky Crane could fly off, crashing a safe distance away.

Ever since, NASA has had Curiosity's 17 cameras on Mars's surface for scientific observations and investigation, including the Mast Cam, which stands 2m high and has provided spectacular panoramas. Curiosity's instruments are also equipped with solar filters which have allowed it to take images of the moons Phobos and Deimos as they partially eclipse the Sun.

The rover also has a 2.1m, triple-jointed robotic arm to prepare and examine samples. Ending in a turret that rotates, it carries a drill, dust removal tool, X-ray spectrometer and the Mars Hand Lens Imager, which works just like a magnifying glass would for a geologist on Earth. Its radiation detectors record exposure to energetic particles and are used to detect liquid or frozen water underground.

Planned to last two years, Curiosity quickly fulfilled a main mission objective by finding rounded pebbles, showing that liquid water had been present for a significant period in the Red Planet's past. It has also found evidence of the chemical building blocks for life, as well as organic carbon and tantalising seasonal changes in the levels of methane, which is quickly lost to space. Methane is often associated with biological processes, although there are other possible explanations.

Having driven more than 28km and explored Gale Crater at a maximum speed of 4cm/sec, today Curiosity's mission has been extended indefinitely and it continues to climb Mount Sharp, analysing exposed sediment layers on the way. There are signs of excessive wear on its front and middle wheels but, as Curiosity uses a nuclear power source that could drive its systems for more than 50 years, the rover could be operating for a long time to come.

▲ Pebbles showing signs of water erosion and smoothing were found by Curiosity

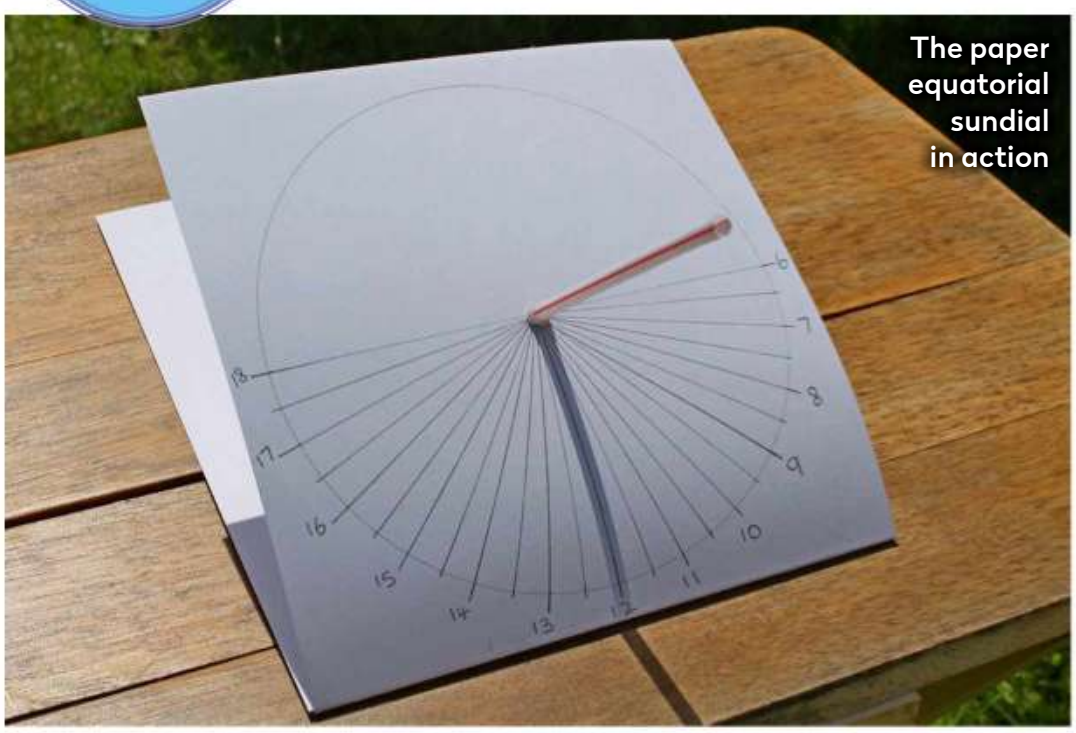
Despite holes in its front wheels, Curiosity will be rolling for many more years

DIY ASTRONOMY

FAMILY FRIENDLY PROJECT

Make a paper equatorial sundial

Tell the time the astronomer's way with a piece of card and a drinking straw



The paper equatorial sundial in action

Our ancient ancestors had to use the Sun as a clock, something it's easy to forget while surrounded by modern devices. A fixed object on a sunny day will cast a shadow and as the Sun moves across the sky that shadow will change position. This basic principle underpins most sundial designs and here we show you how to make a paper equatorial sundial.

The time told by the Sun is specific to your location and may differ from the clocks you have in your home. Local noon sees the Sun at its highest point in the sky. If you are on the Greenwich Meridian line, your local noon will agree with your clocks, but for every degree you are east of that line, local time will be four minutes ahead, while it'll be four minutes behind for every degree west.

Time, gentlemen, please

In our modern interconnected world, time zones have had to be standardised, otherwise bus and train timetables alone would be chaos! The design of sundial we are making here is known as an equatorial sundial, as it utilises the knowledge that the Sun moves at a rate of 15° per hour, therefore any shadows being cast will also move by 15° each hour. We can use this information to create a clock face and with it tell the local time using the shadow cast by the sundial's gnomon (central column or pin).

It is very simple to make from just two pieces of card and a drinking straw, and is an excellent project for families as children can learn about shadows and local time. You can use this sundial to find out the time of local noon at your location.

Technically, our sundial will work for any latitude. But because the latitude scale on the base is not linear, it would need a much longer piece of card and a much longer gnomon to cover the region between 24° north and south of the equator; so our design covers latitudes outside of those regions.

Our clock face is labelled from 06:00 to 18:00, but you can extend that if you wish. The length of the gnomon and the angle of the clock face can be adjusted for your location using the table online.

Our clock face is for the northern hemisphere, but to adapt it for the southern hemisphere simply label your clock face in the opposite direction. When selecting your card, chose something that is sturdy enough to hold its shape but still easy to fold. Because this sundial will work for different locations, you can take it away on holiday with you and see how the result differs from at home.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

MORE **ONLINE**

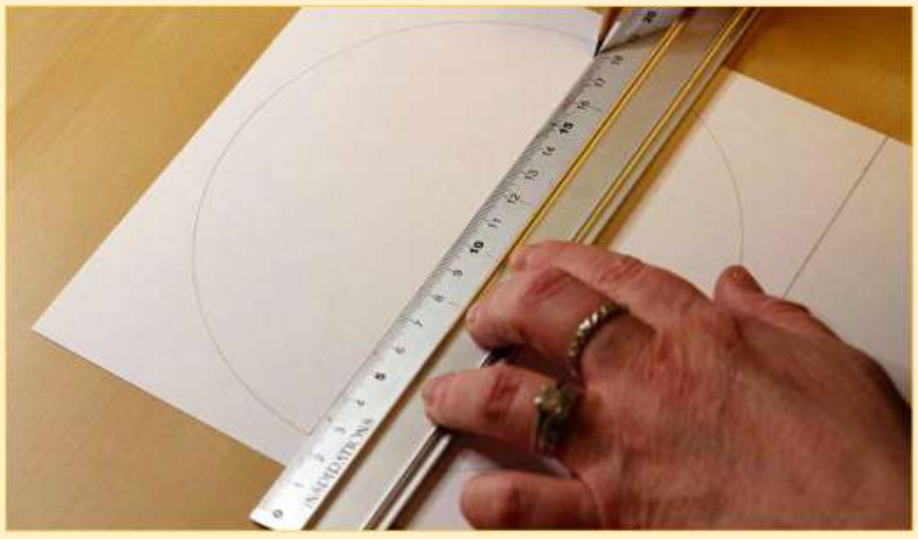
Print a table of the gnomon length and clock face angle for differnet latitudes. See page 5 for details

What you'll need

- Two sheets of white A4 card, sheet A trimmed to 23cm x 18cm and sheet B trimmed to 27cm x 18cm.
- A pair of compasses that will allow you to draw a circle with a radius of 8cm (diameter of 16cm).
- A protractor so you can accurately measure your sundial clock face's divisions.
- A drinking straw to use as a gnomon. We used a straight straw measuring 19cm in length.
- A compass – you can use a traditional compass or a mobile phone to align your gnomon to north (or south if you're in the southern hemisphere).

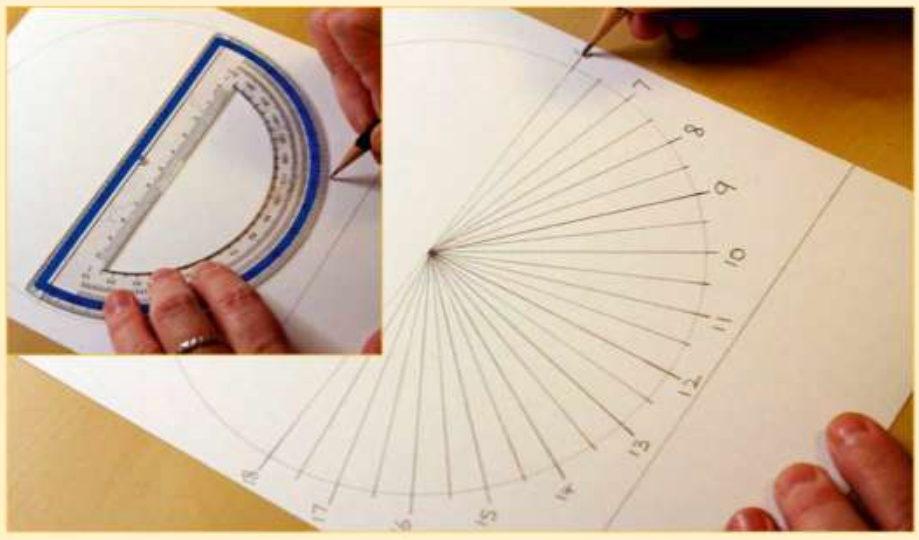
ALL PICTURES: MARY MCINTYRE

Step by step



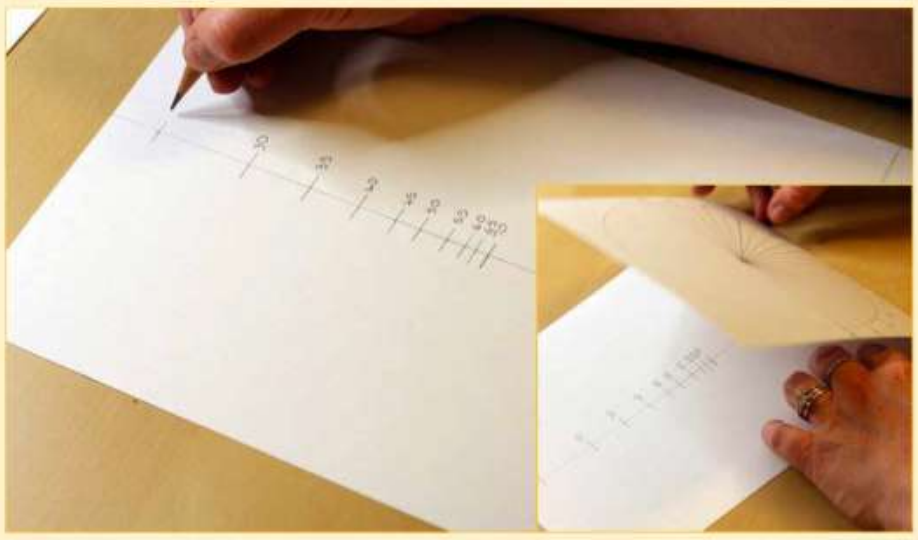
Step 1

Start with card sheet A, long edge up. Draw a line across it 5cm from the bottom; this will be our fold line later. Draw a 16cm diameter circle in the centre of the page above the fold line, then draw a horizontal line across the middle of the circle.



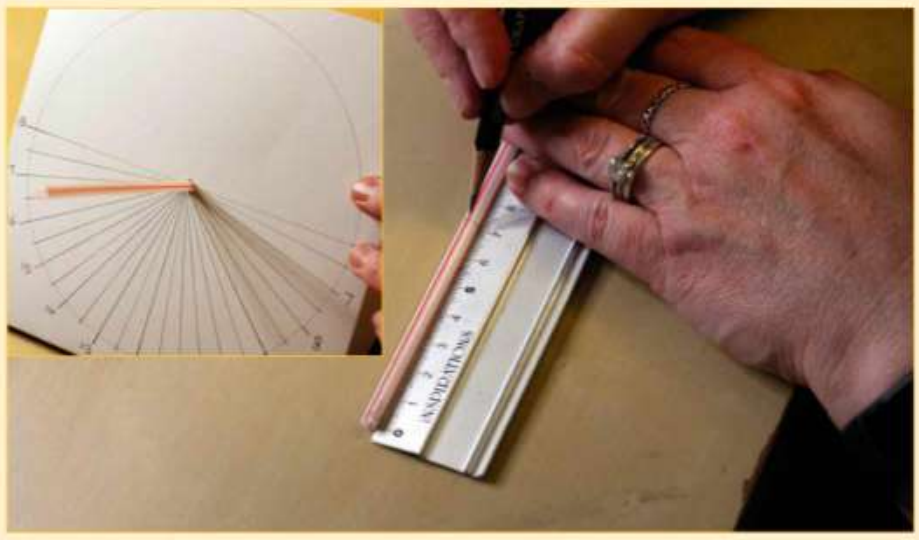
Step 2

Using a protractor, add a mark every 7.5° around the bottom half of the circle's circumference, then draw lines from them to the centre. Starting at the middle line on the right side, label every other line from 06:00 to 18:00, to give the clock face its hour marks.



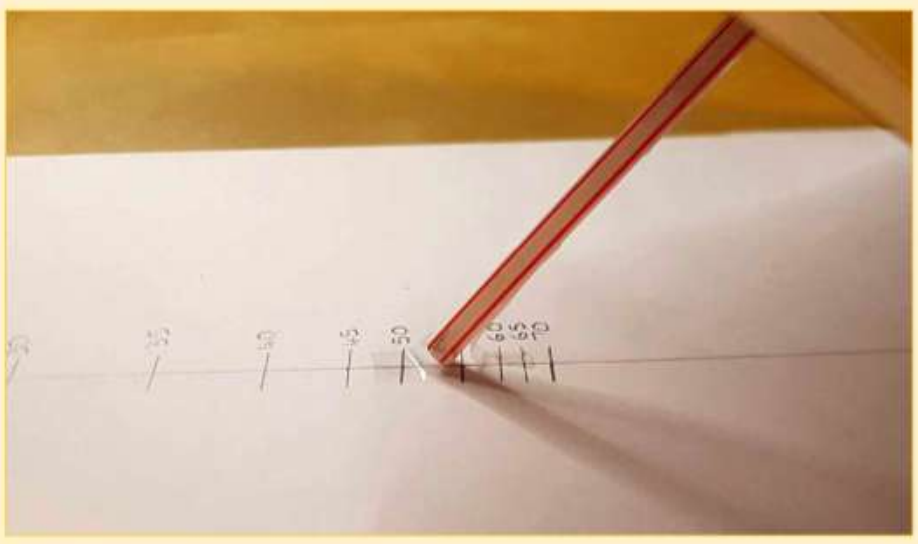
Step 3

On sheet B, draw a fold line 3cm from the bottom, and then a 23cm long vertical line up the middle. Mark this 'latitude line' using the measurements in column two of our table online. Fold the bottom 3cm up, then stick sheet A onto this flap to add the clock face.



Step 4

Measure from the bottom of the gnomon and mark the length that corresponds to your latitude from column three of our table. Make a small hole at the centre of the circle so the gnomon fits snugly, then push the gnomon through as far as your latitude mark.



Step 5

Place the end of the gnomon at the correct position on the latitude line for your location; together with the length shown in column three of the table, this will ensure the gnomon and clock face are at the correct angle. Secure it with a small piece of tape or hot glue.

Step 6

Using a compass, align the sundial accurately with the gnomon pointing north – or south if you're in the southern hemisphere – on a sunny day. Then look where the shadow falls across the clock face and read off the local time for your location.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Bright Moon? Not a problem

The Moon may wash out this year's Perseid meteor shower, but there's always hope

▲ **Composite Perseid image captured on the night of 12/13 August 2014, with a 92%-lit waning gibbous Moon lighting up the sky**

ALL PICTURES: PETE LAWRENCE

Visually, this year's Perseid meteor shower will be something of a washout due to the presence of a bright Moon around the period of peak activity. Photographically, however, there is hope.

A camera set up to do a multi-second exposure of the night sky will typically return a bright, overexposed frame if the Moon is nearby. However, with careful tuning of the camera's settings, it is possible to reduce the intensity of the recorded background sky so that it doesn't overexpose. For example, reducing the camera's sensitivity (low ISO, small aperture) will deliver a multi-second exposure without overexposure. Under normal nighttime conditions, such settings probably wouldn't record many meteors.

To work here, the camera needs to be set to the settings you would normally use for meteor imaging – high ISO and wide aperture – but the exposure time needs to be reduced to prevent sky overexposure. In this way, if a meteor trail passes through the camera frame, it should record just as it would if the sky were darker and the exposure longer. There are caveats though. Shorter exposures mean more shots will be taken. The ideal filetype here is your camera's RAW image format, and such files tend to be on the large side. Lots of large image files means you need plenty of storage available, but for modern cameras this shouldn't be too much of an issue. More frames also require more time to check afterwards.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Mind the gap

The use of RAW means that at the end of each shot a fair amount of data needs to be transferred to your camera's storage card. This can create a 'gap' in your camera's imaging capability, a period when no image is being taken. Under normal 'dark sky' meteor exposure settings, this gap will be far shorter than the exposure time. However, when the Moon is about and exposure times need to be radically shortened, the gap becomes significant.

For example, a one-second gap vs a 29-second exposure means that only two seconds of imaging time is lost per minute (3.3%). However, if the exposure time is reduced to one second, this equals the gap time. Consequently, 30 seconds are lost per minute of imaging time (50%). A shorter exposure also raises the probability of truncating a meteor trail mid-flight, something that increases for brighter and longer meteor trails.

Although not ideal, it is still possible to set up a camera to record this year's Perseid shower and, given clear weather, there's every chance that you will be able to record some trails. And as it's likely there will be fewer people out having a go on the night of the 12th/13th, if you do capture a bright trail you may well be the only one to do so. Follow our How To guide opposite and see what you can catch.

Equipment: DSLR camera, MILC camera, tripod or tracking mount, remote shutter release

✉ Send your images to:
gallery@skyatnightmagazine.com

Step by step

STEP 1

Choose a lens that will give you a good field of view but avoid going too wide as the trails will appear small and unimpressive. Something around the 14–18mm mark would be a good compromise. Have a set of charged batteries ready as well as plenty of storage cards and a lockable remote shutter cable.

STEP 2

The camera will need to be mounted on a stable platform. A tripod will keep the camera still as the sky moves through the field of view. A tracking mount will keep the camera pointing at the same area of sky. If using a tracking mount, make sure the camera doesn't end up pointing at a foreground object.

STEP 3

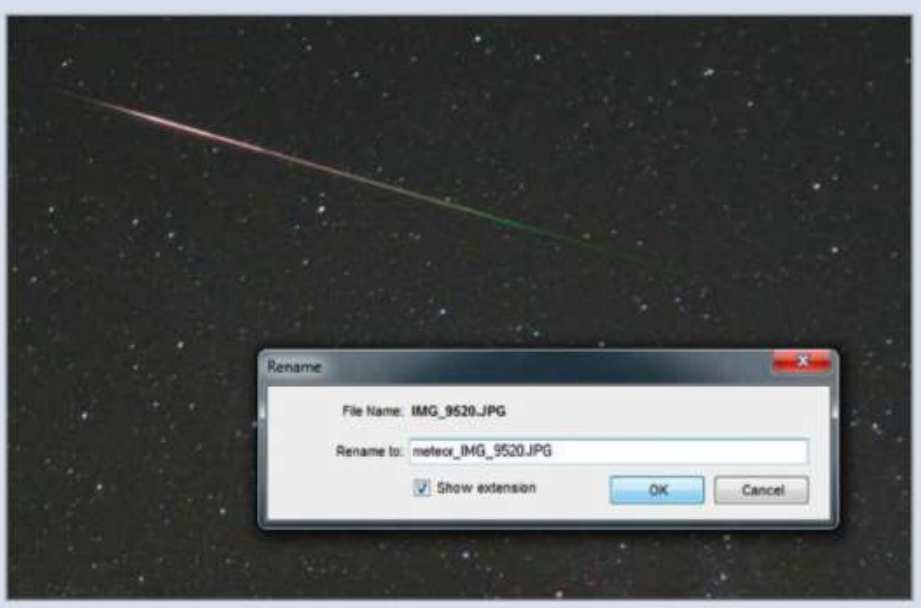
Set camera and lens to manual and check the camera clock. Pre-focus at infinity using a bright target such as Jupiter. Older cameras should be set to an ISO value of 3200 or 6400, while more modern bodies can go further, eg 5000–10,000. Fully open the aperture, reducing by a stop or two if edge stars distort.

STEP 4

Aim at an area of sky that won't bring the Moon into frame. Set a test exposure of 5s and take a shot. Examine the sky. If it's overexposed, reduce the exposure. If it appears dark, consider increasing exposure. Reduce ISO or aperture only if you can't get a non-overexposed sky with less than a 1s exposure.

STEP 5

Set the camera to continuous shutter mode and lock the button down on a connected remote shutter cable. The camera should continuously take shots at the pre-set exposure. Routinely check the lens for moisture, using a 12V hairdryer to remove any. A 12V heater band is a recommended alternative if you have one.



STEP 6

Capture for as long as you can. Download the results. Using a viewing app, examine each image in turn. Renaming any suspected trail images with a prefix (eg 'meteor_') makes them easier to find later on. Perseid trails should align with the radiant and often show green-pink coloration.

APY Masterclass

Capturing Venus and the Moon

Lighting Venus's crescent and the lunar limb evenly is no small feat

Astronomy Photographer of the Year
2021 shortlisted entrant in the 'Our Moon' category

The final shortlisted APY 2021 image: Beyond the Limb

Ever since I first became interested in astronomy, I have been fascinated by the iconic images of Earth rising above the lunar horizon from the Apollo missions. When I realised that the Moon's occultation of Venus, visible on 19 June 2020, would give me the opportunity to capture a similar image for myself, it immediately became one of my astrophotography aims of that year. I decided to capture the event with a very narrow field of view in order to enhance the 'crescent over lunar horizon' feeling and I also wanted to capture the event in colour to record the daylight blue sky. To achieve this, I used my Celestron C11 equipped with a colour planetary camera at prime focus.

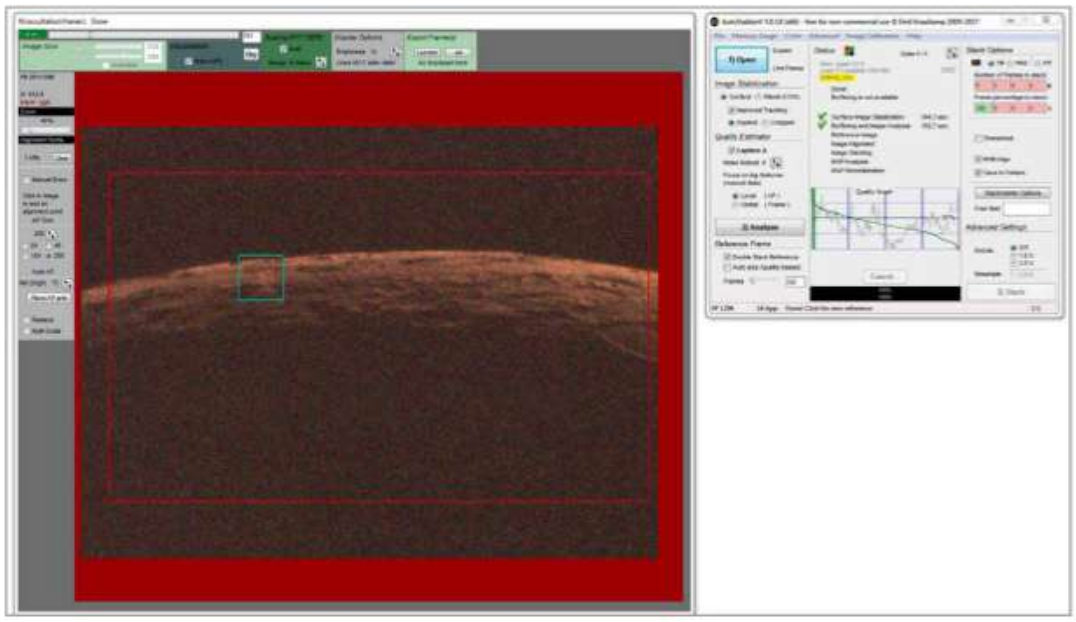
In order to achieve a natural look to the image, I chose short exposures so as not to oversaturate bright Venus. This made the crescent Moon's limb barely visible in the shots (see image, right). To compensate for this low contrast I had my planetary camera's gain set to zero, so the noise in individual frames would be as low as possible. Unfortunately, some low cloud moved in during the capture a few seconds after the Moon began to hide Venus, and obscured the scene. When the sky was blue again, Venus had totally disappeared, so I took more shots of the Moon, this time with longer exposures to better reveal the details of the lunar limb.

The initial capture, with Venus in view and a very faint lunar limb

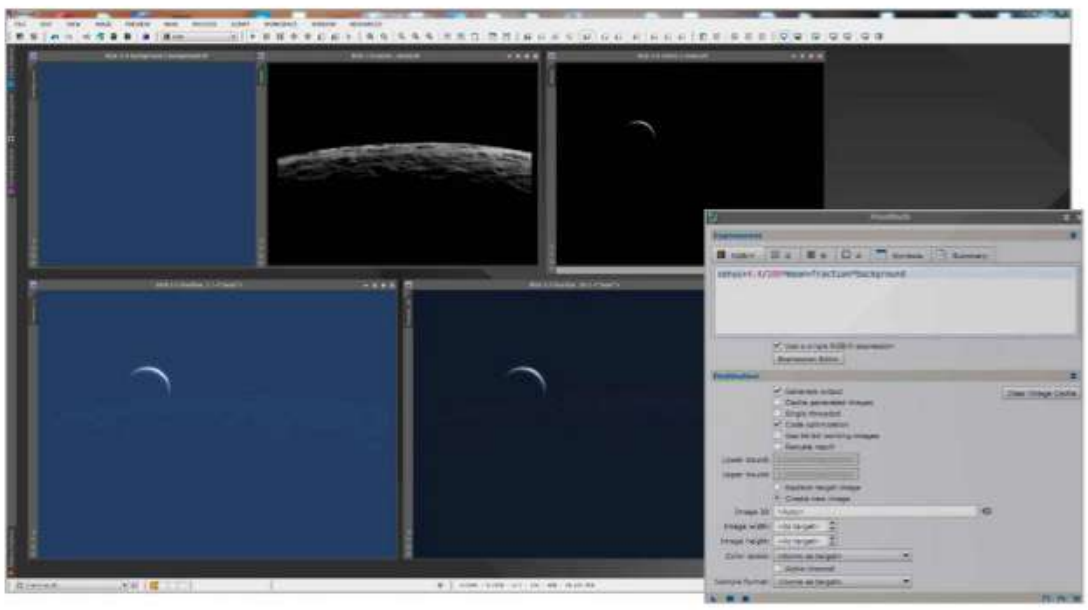
ALL PICTURES: NICHOLAS LEFAUDEUX

Stacking Venus

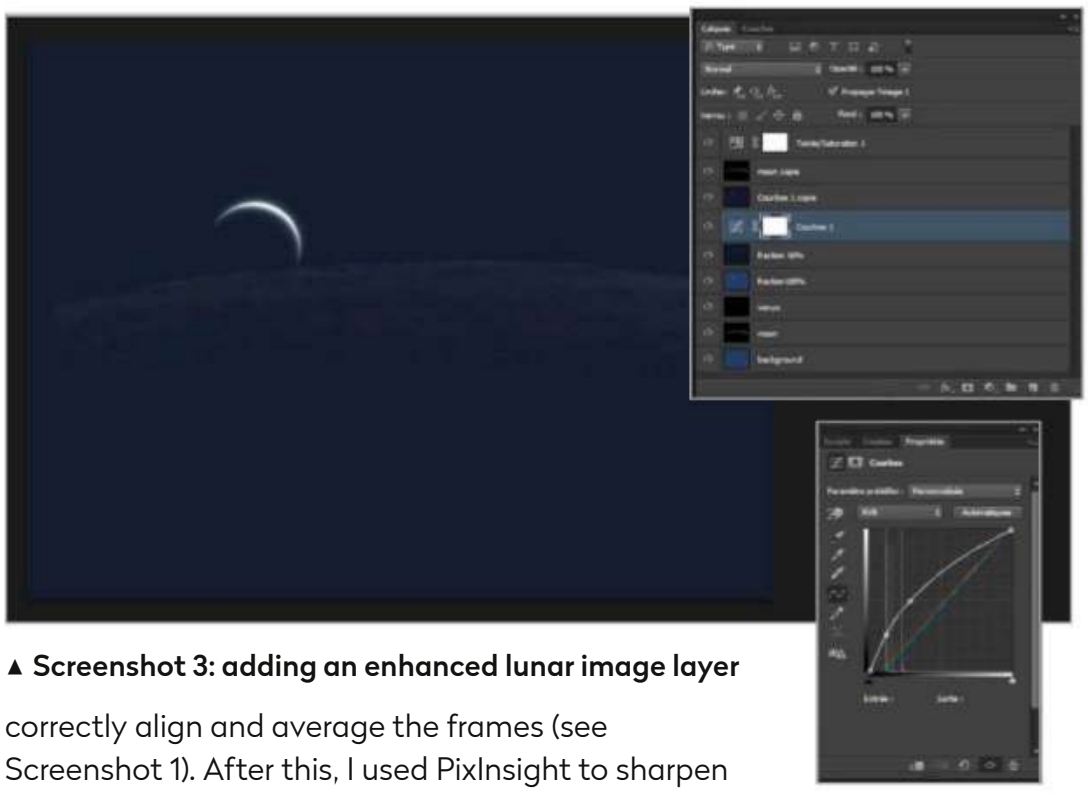
For the processing, I started with AutoStakkert! to extract frames for stacking from the video captures and to improve image quality and sharpness. Stacking the bright Venus frames was straightforward, but for the Moon data the software wasn't able to correctly align the frames due to their low contrast. I had to export these frames, pre-process them to improve contrast, and then reload them into AutoStakkert! so that the program would



▲ **Screenshot 1: stacking the preprocessed lunar images in AutoStakkert!**



▲ **Screenshot 2: compositing Venus, lunar and blue sky images with PixInsight**



▲ **Screenshot 3: adding an enhanced lunar image layer**

correctly align and average the frames (see Screenshot 1). After this, I used PixInsight to sharpen the averaged images of Venus and the Moon, using tools including deconvolution and wavelets.

I took care not to over-enhance the details, which would ruin the natural appearance I was looking for in the final image, and made sure that the final sharpness of Venus and the Moon was similar in order to avoid discrepancies in the final composite. Then I positioned the sharpened images of Venus and the Moon using a frame that corresponded to the beginning of the occultation. I chose a frame in which the crescent of Venus was not hidden by the Moon to avoid having to manage the fact the Moon was hiding some part of the planet. I also created a background image with the RGB values of the blue sky I had extracted from the captures.

3 QUICK TIPS

1. Have several scopes and cameras that can be used in multiple combinations and adapted to different subjects.

2. To obtain a natural aspect to the final image, avoid over-enhancing or over-smoothing to ensure image consistency.

3. Flip your image left/right during processing to see it with a new eye for a few seconds.

Blending insight

I now had three images of the exact same size: one of the Moon and one of Venus matching the instant before the beginning of the occultation and one of the blue sky background that I had to blend to get the final image. Rather than simply overlaying the images, I used PixInsight to blend them. I added the three images to the program using the Pixel Math function, with the right coefficient corresponding to the actual brightness of the three images (see Screenshot 2). From this, I generated several outputs with either full background or partial reduction of the background, to help with the visibility of the lunar details. Where possible, I preferred to blend first, then stretch the image, staying close to the actual light intensities to avoid introducing an unnatural appearance.

I used Photoshop for the final adjustments. Here I adjusted the image curves to improve the visibility of the Moon and used hue and saturation to alter the colour of the background. Despite this, I found that the Moon was still not visible enough to convey the feeling I was looking for in the final image, so I slightly increased its visibility using my enhanced Moon image as a layer (see Screenshot 3). I had to keep this enhancement subtle, otherwise it quickly showed the noise in the Moon image, which gave an unnatural look.

However, I ended up deliberately adding some noise into the image to give some texture to the uniform blue background and slightly reframed it to get the view of the Venus crescent hovering above the lunar horizon, which I had been dreaming of. This became the final 'Beyond the Limb' image that was shortlisted for APY 2021.

Nicholas Lefaudeux is an optical engineer and amateur photographer. He has been awarded an APY in different categories in 2018, 2020 and 2021

Your best photos submitted to the magazine this month

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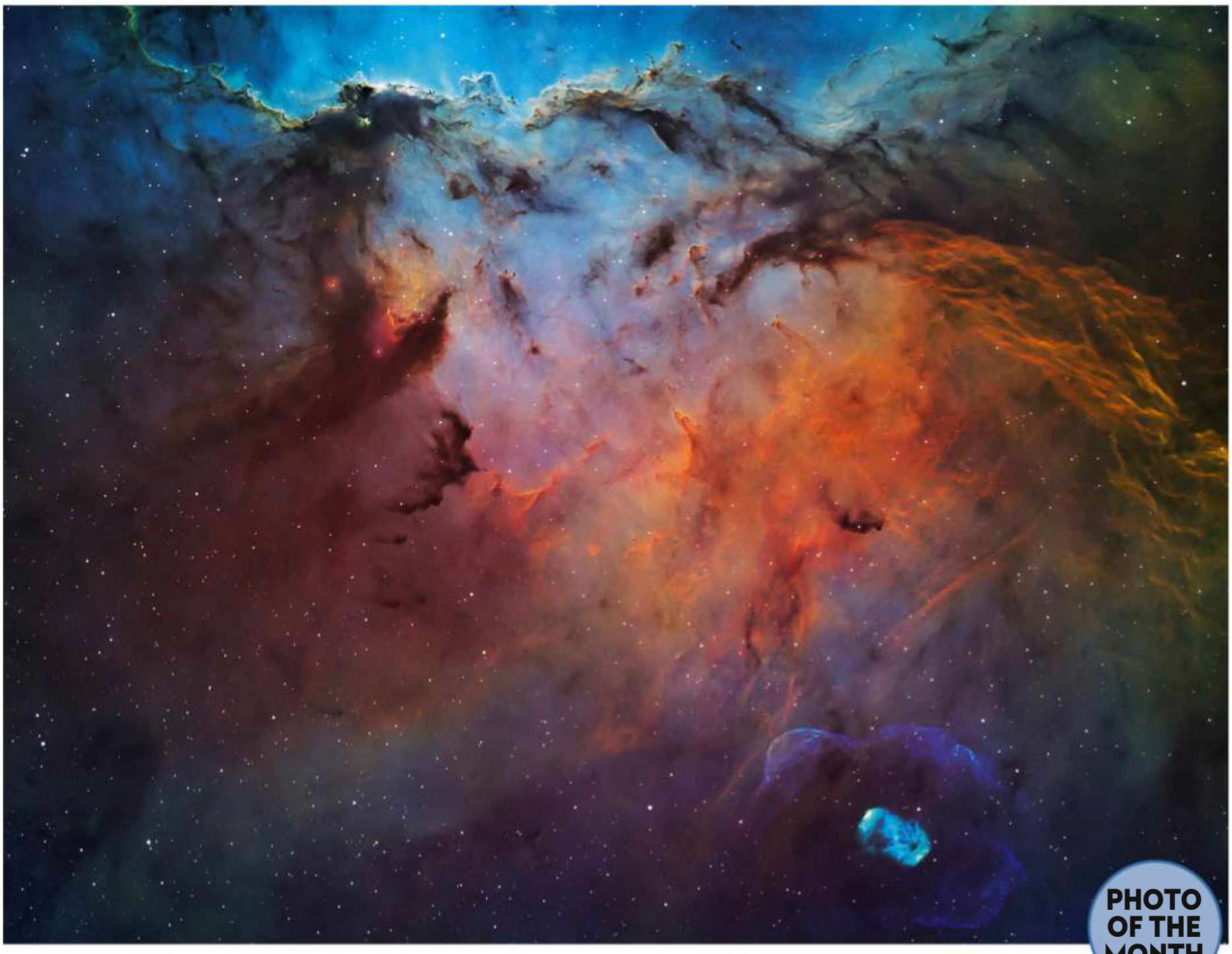
A gallery containing these and more of your images



△ NGC 6188, The Dragons of Ara

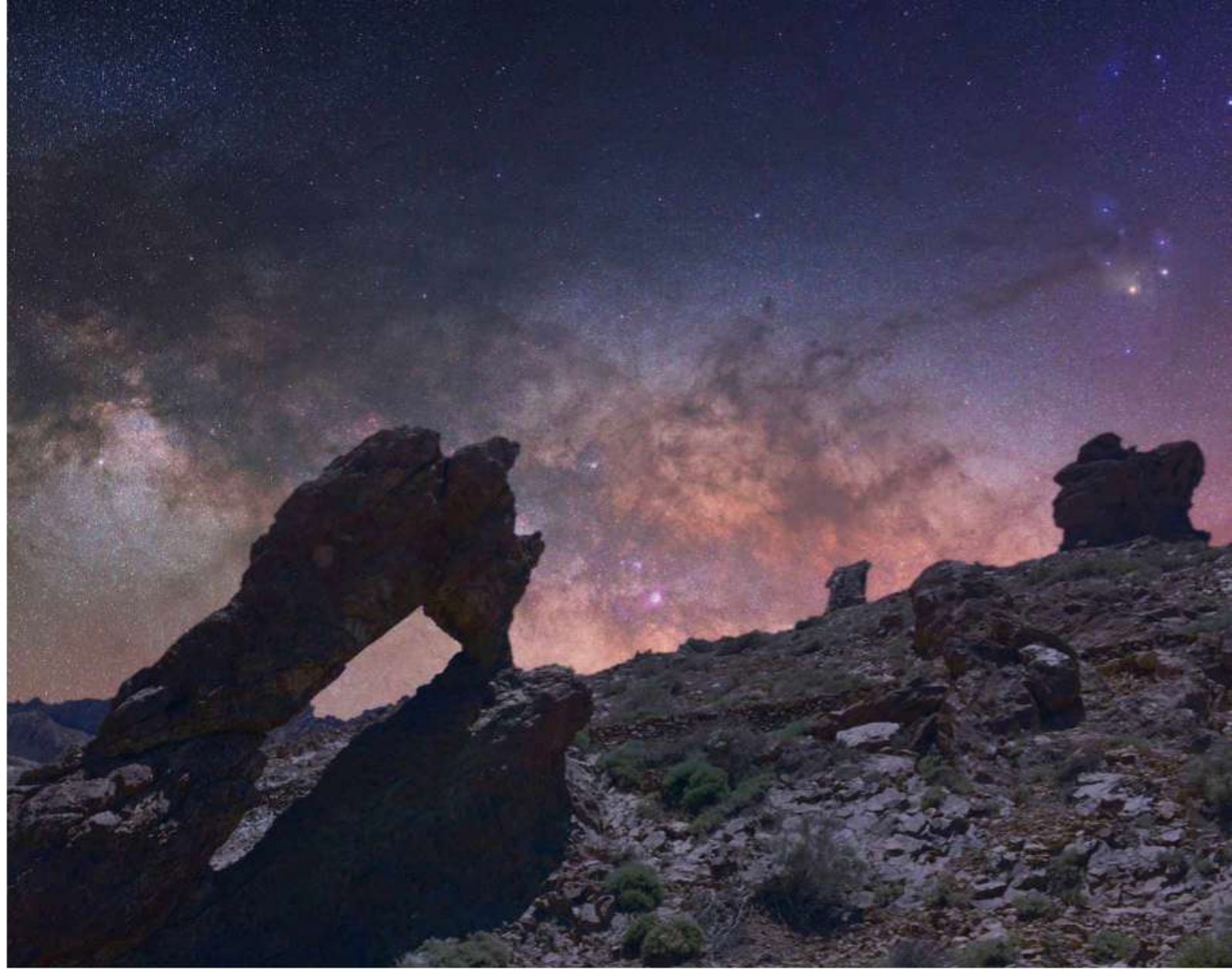
Shaun Robertson, Melbourne, Australia, 10, 25, 26 and 29 April 2022

Shaun says: "This has been my favourite target since I started this hobby two years ago. The strong emission across each filter and the great separation of channels makes it the perfect image to work and experiment with. This was my second attempt at it, with much cleaner data and some more experience in processing than I had last year."

Equipment: ZWO ASI1600GT camera, Sky-Watcher Esprit 100ED refractor, Sky-Watcher EQ6-R Pro mount **Exposure:** Ha, SII and OIII 180x 300" each, 15h total **Software:** PixInsight, Photoshop

Shaun's top tips: "Take your time. First, in framing your target: some nebulae have beautiful star clusters nearby, for example, so moving your target off-centre to include those can make a huge difference. Stellarium is great for planning this. Secondly, in gathering as much data as possible and in processing: process each filter's data before combining your channels. Careful stretching reveals detail and improves the dynamic of the image. And lastly, do what appeals to you. There is no set 'standard image' in astrophotography and for me it is a blend of art and science."

The Milky Way core ▷



Steve Fox, Teide, Tenerife, 22 March 2022

Steve says: "The sky was amazing at this location. In fact, polar aligning wasn't easy because there were so many bright stars around – something I'm not used to back in the UK!"

Equipment: Canon EOS R6 mirrorless camera, Sigma Art 24mm lens, iOptron SkyGuider Pro, Velbon DV-7000N tripod **Exposure:** ISO1000 f/2.8, 8x 60" **Software:** APP, Affinity Photo, GIMP

△ Mare Imbrium close-up

Roger Hyman, Sparkford, Somerset, 13 January 2022

Roger says: "With the help of a TeleVue Powermate 4x amplifier I managed to get this detailed capture of one of my favourite areas of the Moon."

Equipment: Altair Hypercam 183C Pro camera, William Optics Zenithstar 126 refractor, Celestron CGX mount **Exposure:** best 25% from 500 frames at 12.5ms, 200 gain **Software:** AutoStakkert!, Photoshop, Topaz DeNoise

▽ Flower Moon rising over Christ the King

Mara Leite, Almada, Lisbon, 16 May 2022

Mara says: "This is a single exposure, taken at around 10pm from the opposite bank of the Tagus. The sky cleared just before moonrise. I couldn't believe my eyes."

Equipment: Canon 5D Mark IV DSLR, Sigma 70–200mm lens with 2x extender, Manfrotto 190Go! tripod **Exposure:** ISO 6400 f/13, 1/125" **Software:** Adobe Camera Raw, Photoshop

◁ The Iris Nebula

Mark Johnston, Chiricahua National Monument Arizona, USA, 29 May 2022

Mark says: "This site was a 3.5-hour drive each way, but worth it for the pitch-black skies and a naked-eye view of Omega Centauri."

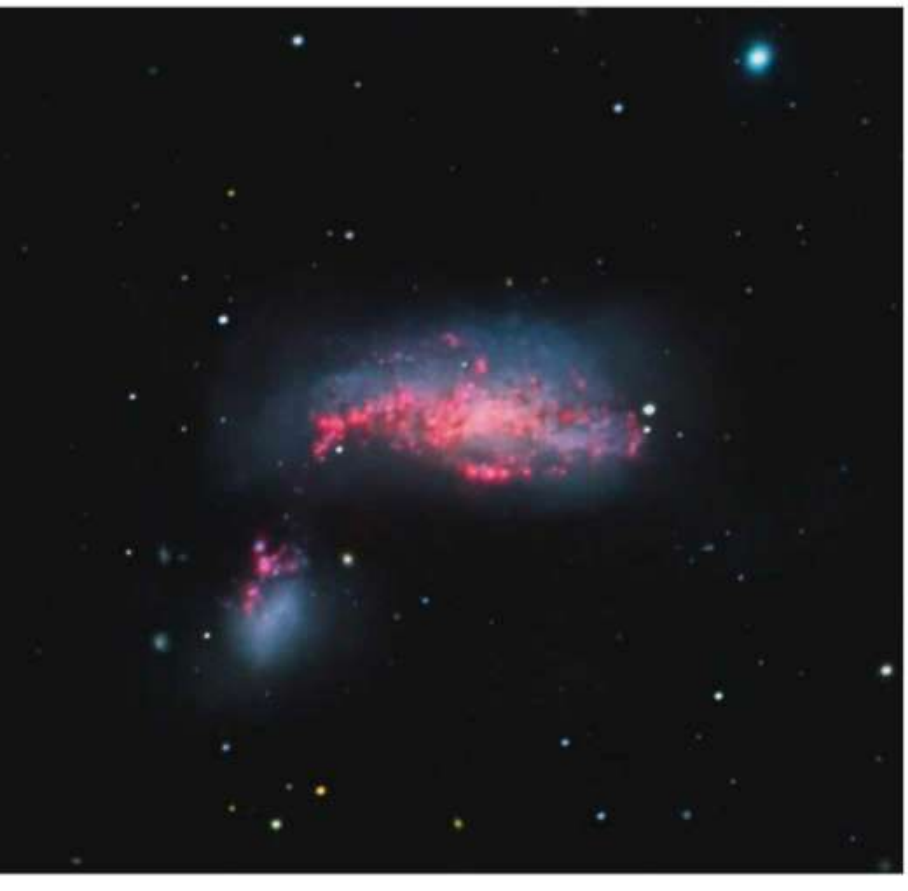
Equipment: ZWO ASI183MC Pro camera, Celestron 9.25-inch Hyperstar Schmidt-Cassegrain, TTS-160 mount **Exposure:** 41x 120" **Software:** Affinity Photo

Waxing crescent Moon ▷

Stacey Downton, Longbridge, Birmingham, 5 May 2022

Stacey says: "This is the first image I captured on my brand-new telescope and is a mosaic made up of 2,000 frames."

Equipment: Altair Astro GPCAM 290C camera, Altair Astro 8-inch f/5 Newtonian, Sky-Watcher EQ6-R mount **Software:** AutoStakkert!, MICE, Photoshop

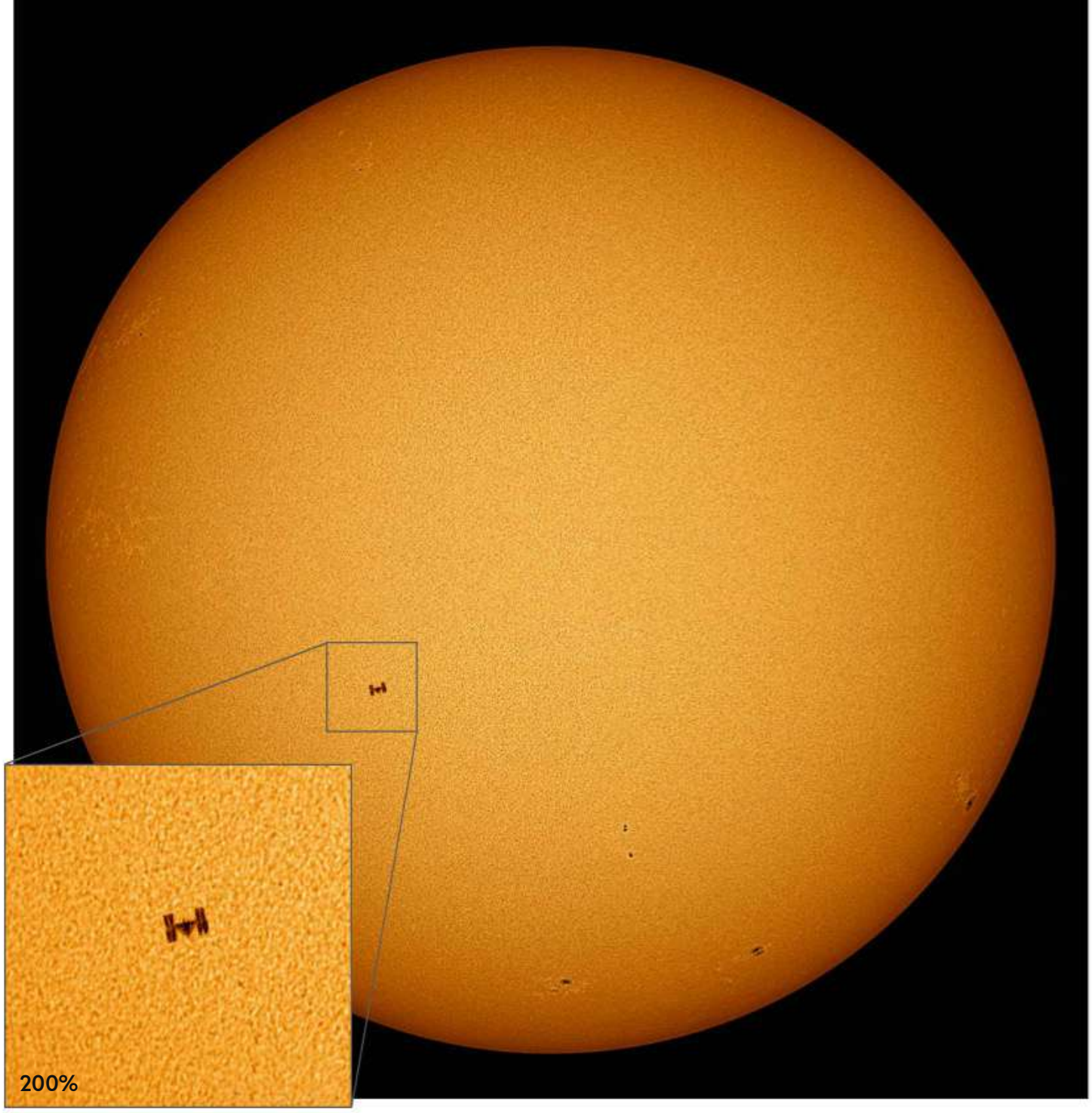


◁ The Cocoon Galaxy

Mark Shelton, Birmingham, 30 April, 5 May 2022

Mark says: "This target can be a challenge. It's small and requires a large-aperture telescope to show appreciable detail. I had to pay close attention to guiding and focus."

Equipment: ZWO ASI6200MM camera, Celestron C14 Schmidt-Cassegrain, Paramount MX+ mount **Exposure:** LRGB 5h, Ha 6h **Software:** PixInsight, Photoshop



◁ The ISS crossing the Sun

Jamie Cooper, West Haddon, Northamptonshire, 4 June 2022

Jamie says: "It wasn't an optimal pass, with the ISS only 36 arcseconds across and the setting Sun fairly low at 36° altitude, but this six-pane mosaic is a pleasing result for a first attempt."

Equipment: ZWO ASI290MM camera, unbranded 102mm refractor, Baader AstroSolar film, ZWO green filter, Sky-Watcher EQ6 mount
Exposure: 2,500-frame video, best 40% frames stacked
Software: AutoStakkert!, RegiStax, Photoshop

The Sunflower Galaxy ▷

Ron Brecher, Guelph, Ontario, 29 January–11 May 2022

Ron says: "This was six months in the making, mostly under Moon-free skies, captured in between other projects."

Equipment: QHY367C camera, Takahashi FSQ106ED refractor, QHY600M camera, Sky-Watcher Esprit 150ED refractor, Paramount MX mount
Exposure: 35h 15' total
Software: PixInsight

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hama

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86 **Find out why Altair's updated 130EDT-F refractor goes above and beyond our expectations**

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

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@THESHED/PHOTOSTUDIO

Altair Wave Series 130EDT-F F7 apo refractor

A winning performance for observing and imaging, on a par with pricier scopes

WORDS: TIM JARDINE

VITAL STATS

- **Price** £2,499
- **Optics** Air-spaced triplet
- **Aperture** 130mm
- **Focal length** 905mm, f/7
- **Focuser** 92mm rack and pinion with 1:10 gearing
- **Extras** Aluminium storage case
- **Weight** 12kg with rings and Losmandy bar
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.** altairastro.com

The Altair Wave Series 130EDT-F has been updated for 2022, with upgrades that will be popular with both observers and astrophotographers. Large refractors like this 130mm triplet always have a special air about them, they look like a proper telescope, as it were, and the 130EDT-F is certainly impressive, while the quality and build are exceptional. The tube rings, for example, come complete with carrying handle and are finished in red anodising. They are meticulously machined with bevelled edges and give an indication of the attention to detail that has been lavished on the fit and finish of this telescope.

Another upgrade is to the dovetail bar, which now has a Losmandy-style profile. We found this helped with balancing the 130EDT-F, something which can prove a little tricky with large refractors. Weight-wise, the package tips the scales at around 12kg, which is perhaps on the hefty side, but reassuring that the materials used are solid and robust enough to provide years of enjoyment when investing in this telescope.

With a focal length of 905mm (f/7) the 130EDT-F hits the sweet spot for observing and photography alike. Additional options are available to enhance the photographic ability of the telescope, including a dedicated flattener. We were loaned a matching 0.8x PlanoStar reducer lens, which took the focal ratio down to f/5.6.

Looking sharp

With a brief window of clear skies available, our first light from the telescope came from a CCD camera without the reducer, the target being the Hercules globular cluster, M13. These initial images demonstrated that the triplet lens was producing sharp, distinct stars and the surrounding star field was free from any optical issues. Suitably impressed, we turned the scope towards the supernova which had appeared in NGC 4647, and almost without effort ▸

@THESHED/PHOTOSTUDIO X 5, TIM JARDINE

M92 focuser

The focuser is an M92 (92mm) rack and pinion design with dual speed controls. The drawtube has graduated markings for quick repeatable setup and it is smooth and accurate in use. Dual rotation options, a self-centring clamp and a finderscope shoe round off this impressive unit.

Clamp rings and Losmandy bar

A full-length 335mm Losmandy-style bar provides a solid and firm base for the tube rings, with no unwanted flexing. The carry handle serves a dual purpose as an accessory rail, with options for attaching a guidescope or similar, while the rings themselves have additional threaded holes for attachments.

Dew shield

The dew shield is nicely made and slides smoothly, with 138mm of travel and no flopping when fully extended. With the tube rings in place it only retracts about 76mm, but taking the tube out of the rings allows full retraction and access to the lens for cleaning. The lens cap is aluminium.

Removable section

The rear 100mm section of the tube is removable. This helpful upgrade allows observers with binoviewers to attach them directly to the telescope with no Barlow lens. Considering our results with a single eyepiece, this would likely make a formidable wide-field instrument when assembled with a binoviewer.

FIRST LIGHT

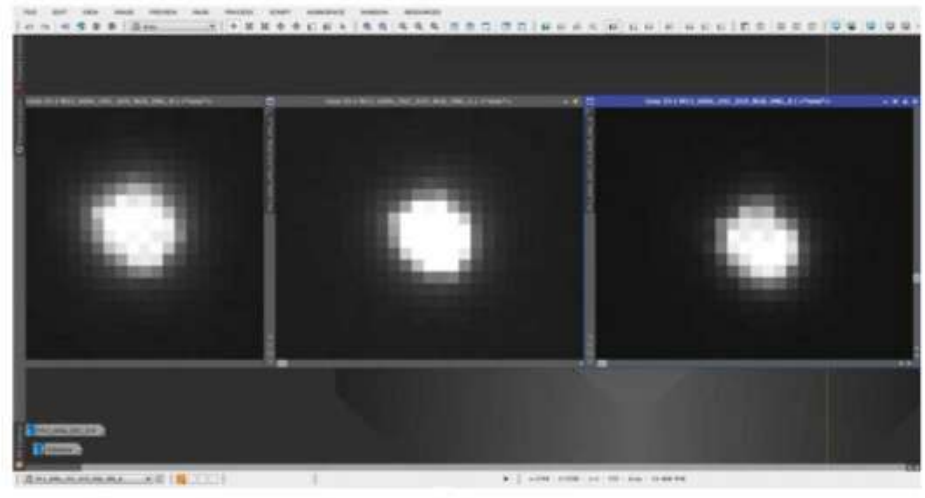
Shipping case

The telescope is supplied in an aluminium transport case with foam inserts for protection. Although Altair Astro points out that it is just for preserving the telescope during shipping, it will make a useful and safe storage box while the scope is out of use, and has locking clasps.

Air-spaced triplet lens

Altair Astro provides an optical guarantee with the Wave Series refractors – each unit has a minimum performance level. Each telescope comes with a printed optical report relating to the serial number on the lens. Our review model boasted an impressive 0.972 Strehl reading, which is a measurement of optical quality, with 0.95 being the baseline for the Wave Series.

The proof of the pudding is in the eating, though, and our results both with a camera and an eyepiece do bear those figures out. Taking an edge-of-field star, captured by our one-shot colour CCD camera, we split the channels into red, green, and blue, blew the image up to 25x and compared the star sizes. There was negligible observable difference between the star sizes, demonstrating that the triplet lens, having been carefully aligned, performs its job of bringing all three colours into a single point of focus. This optical performance makes the 130EDT-F a desirable telescope for use with increasingly popular and capable one-shot colour astronomy cameras, and certainly with an eyepiece.



▲ Blown up and split into red, green and blue channels, an edge-of-field star showed little distortion thanks to the capable lens

@THESHED/PHOTOSTUDIO X 2, TIM JARDINE X 4

With an Atik 460EX camera, in 10' exposures the 130EDT-F delivered distinct and sharp stars in M13 (4h 40' total)

▸ the large optics revealed not only the exploded star itself, but dozens of smaller, far fainter distant galaxies. Considering the images were taken in suburban skies in late spring without astronomical darkness, they provide convincing evidence for the good, contrasty views from the 130EDT-F, no doubt helped by the lens coatings and internal baffles.

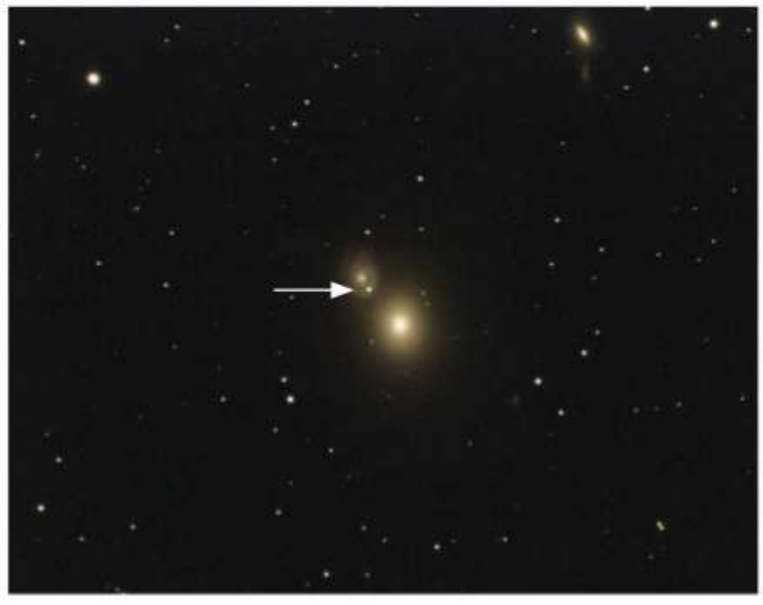
Eyepiece excellence

As the Moon became dominant, we switched to visual use of the telescope, using our own diagonal and eyepieces. Our 13mm, 100° eyepiece gave 70x magnification, and on the Moon, illuminated about 50 per cent or so; high in the sky, the results were breathtaking: the Moon almost appeared to be in 3D. Triplet telescopes are perhaps a luxury for observational use, but presented with views like these, that luxury seems perfectly justified. Switching to our 4.5mm eyepiece ramped up the magnification to 200x, which was pushing the seeing, but glimpses through steadier patches revealed craterlets within craters and definition inside illuminated crater walls, all without distracting colour artefacts on bright edges.

Our favourite view came from our 10mm eyepiece though, at 90x, with sharp views of craters, ridges and flows within the lunar maria. The skies weren't really dark enough for deep sky objects, but M13 was visible with reasonable contrast and good distinction between stars, and we even got both galaxy cores from M51, thanks to the telescope's 130mm lens.

Our observing notes included this sentence: "This is the kind of telescope that could tempt an astrophotographer to leave the camera and fit an eyepiece instead, offering lovely crisp views that are comfortable to observe." We did go back to the camera though, this time with the 0.8x reducer in place, which screws firmly to the focuser. Again we were very impressed with the images and the 130EDT-F proved itself very capable on galaxies and the Iris Nebula. In particular, the updated focuser was a joy to use. Not only is it slick and responsive to work with, but locking the position was accurate without pushing the image off. The whole focuser can be rotated, or just the camera, with easy-to-use fittings.

In short, the 130EDT-F is an all-round, high-quality large refractor, providing excellent views and images comparable to more expensive telescopes.



▲ Picking out the Sombrero Galaxy, M104, with the same setup using 1h 20' of 10' exposures

◂ Capturing the blast of the supernova in NGC 4647 and far-distant galaxies

VERDICT

Build & design	★★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging Quality	★★★★½
Optics	★★★★½
OVERALL	★★★★½

KIT TO ADD

1. Altair Astro PlanoStar M92 1.0x reducer

2. Altair Astro PlanoStar M92 0.8x reducer

3. Altair Astro 60mm guide scope, Vixen bar rings and GPCAM2 guide camera combo

Explore Scientific 4K Planetary & Deep Sky Astro Camera

Capturing deep-sky targets, the Moon and planets – can one camera do it all?

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £533
- **Sensor** Sony 8.3MP IMX485 Exmor CMOS sensor
- **Output format** Image: 3840 x 2160 pixels (4K). Video: 1920 x 1080 pixels (full HD)
- **Frame rate** Up to 43 and 66 fps (for video)
- **Exposure range** 0.1 ms to 60 minutes
- **Connectivity** USB3 and ST4 ports
- **Physical size** 85 x 68mm
- **Weight** 300g
- **Extras** Software CD, 1.25-inch nosepiece, 1.5m USB3 cable, 1.5m ST4 cable, dust cap
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.**telescope house.com

With the growing interest in CMOS imaging cameras, we take a look at Explore Scientific's latest entry-level offering. The 4K Planetary & Deep Sky Astro Camera is a passively cooled CMOS camera that comes fitted with the new Sony IMX485 Exmor CMOS colour sensor. Once out of the box, we were pleased to find that the camera has an entirely aluminium body with no plastic in sight. Included in the package is a 1.25-inch nosepiece, a 1.5m USB3 cable, a 1.5m ST4 cable, a snug-fitting rubber dust cap and a software CD. For those that don't have a PC with a built-in CD drive, all the latest software, drivers and instruction manuals are also available to download from Telescope House's website.

This software, called Explore Capture, has the ability to run video, a useful boon for planetary imagers, and can be switched to long-exposure settings for deep-sky imaging.

We started by running a few long-exposure dark frames to get an early impression of the level of unwanted noise artefacts present and were immediately impressed. Using the black level and gain settings recommended in the user guide, we worked our way through different exposure lengths, up to five minutes. Right the way through, the noise present in the images remained impressively low. However, there was a significant amount of amp glow present, visible in every image across the entire top and bottom quarters.

Download hiccups

During these tests we also discovered that the 4K Planetary & Deep Sky Astro Camera was very sensitive to the computer it was plugged into. Despite connecting to the USB3 port on our imaging PC, we couldn't download images over two minutes long. When we switched to video mode, we were only saving three frames per second (fps), despite it being set to capture 40+ second exposures. Switching to our laptop didn't improve things, despite both machines having high-specification i5 processors and 8GB RAM. Sensing that the issue could be the age of both computers, we tried another, newer PC with an i7 processor and 16GB RAM, and found that download ▸

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Fan cooling

This is a passively cooled camera that contains a built-in fan at the rear and a large air intake, which helps to keep the sensor cool and contributes to the low noise present in the images. The fan can be switched on or off via the included software if needed.

Compact size

The camera has a body only 86mm long by 68mm in diameter and, due to the small sensor size and aluminium construction, only weighs 300g. The small size means it can be mounted to lightweight portable setups without causing weight issues.

Connectivity

Connected and powered via a supplied 1.5m USB3 cable, the camera was easy to connect. Downloading the latest drivers and software was quick and easy, and once the camera was connected it was instantly detected by Explore Capture and ready to use.

Guider port

Located on the back of the camera is an ST4 port that allows direct connection to most telescope mounts. An ST4 cable is supplied in the box. When connected to appropriate software (not supplied) it turns the 4K Planetary & Deep Sky Astro Camera into a very sensitive guide camera.

FIRST LIGHT

Software

The camera comes with Explore Capture software, which has both video and long-exposure settings and a helpful Auto function to get you up and running quickly. The software also includes a handy image-editing capability which is useful for post-capture processing.

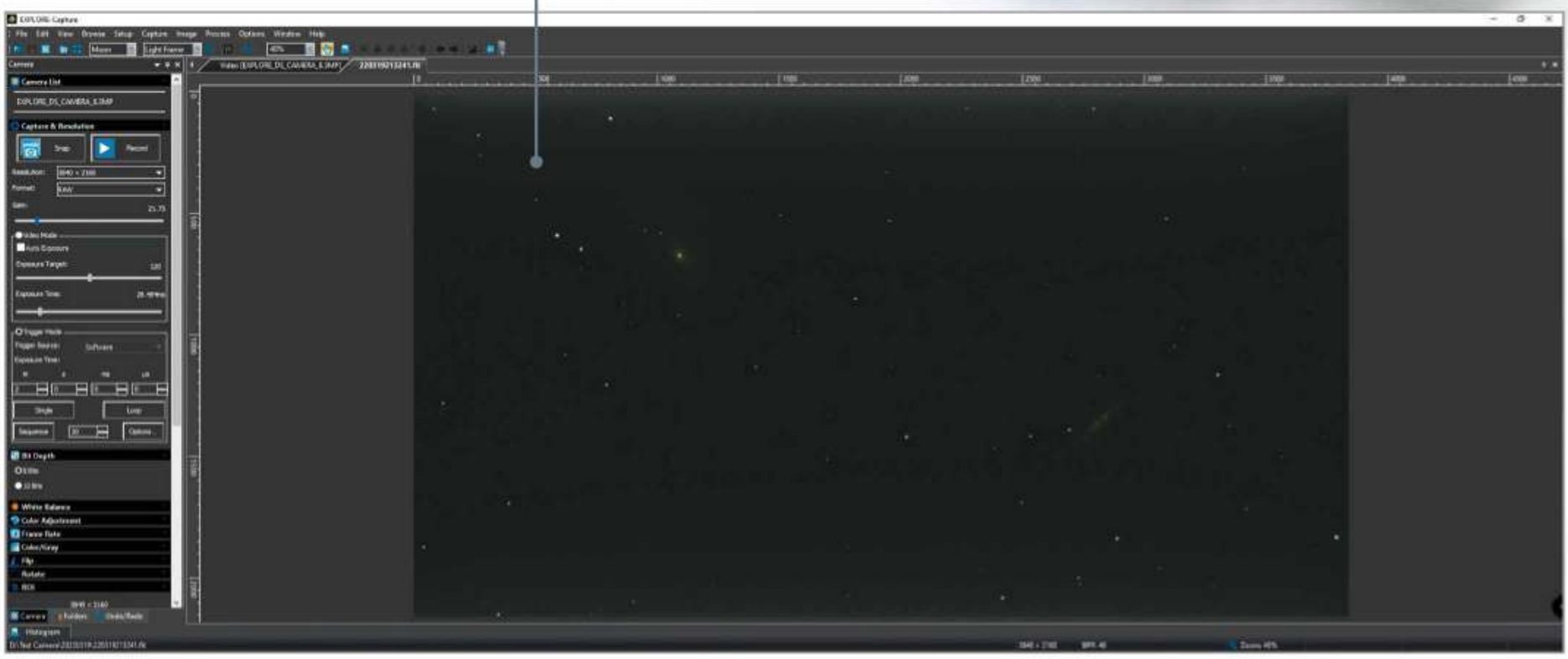
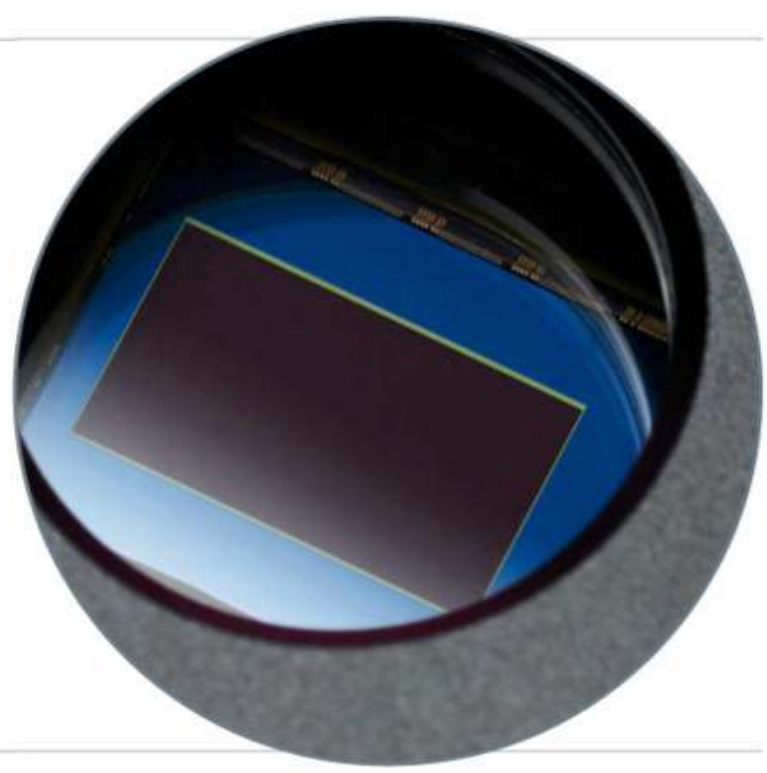


Image sensor

The 4K Planetary & Deep Sky Astro Camera is equipped with the latest Sony IMX485 Exmor CMOS back-illuminated colour sensor that packs 3,840 x 2,160 pixels into a sensor 11.14mm x 6.26mm in size. The IMX485 has a pixel size of 2.9µm, which makes it a good match for refractors in the f/6–7 range, but a little small for longer focal-length reflectors that are popular for deep-sky imaging. The Sony IMX485 has a bit depth of 8 or 12, switchable in the Explore Capture software. At 12 bit, image files are larger and so download speeds for video will be more affected.

The sensor is extremely sensitive in low light and produces very little noise, separate to the amp glow issue, even when gain is pushed above the recommended settings. The low-light abilities of this sensor made alignment and focusing a quick and simple process, and finding a guide star was super-easy. Both Bode's Galaxy, M81 and the Cigar Galaxy, M82 could easily be seen in Live View, which allowed us to adjust and frame the objects with ease.



@THESHED/PHOTOSTUDIO X 2, CHRIS GRIMMER X 3

◄ Our reviewer was impressed to see both M81 and M82 in the camera's Live View. 65x 120" exposure, with a William Optics GT81

► The 8.3MP sensor produced crisp images of the Moon in a single 2-minute video using a Meade 8-inch Schmidt-Cassegrain

► speeds improved, but we were still limited to a maximum of 13fps at full frame. Switching between 8 and 12 bit and saving in different file types made no noticeable difference.

Moon magic

Once the skies started to darken, we fixed the camera up our 8-inch Schmidt-Cassegrain telescope and swung it up to the half Moon. The Explore Capture software has a very good Live View function, which made alignment and focus easy, while the camera's 8.3MP sensor had a good field of view and produced a very crisp and clean image. With the settings on 'Auto' the software selected the best frame rate and gain settings for the ideal exposure of whatever area of the image we selected. Capturing two-minute videos in both SER and AVI format gave us between 157 and 417 frames at a maximum rate of 3fps. Reducing the region of interest to 1,200 x 1,000 pixels increased the rate to 18fps.

After the Moon had set, we swapped setups and attached the camera to our 80mm refractor, slewing it to the Cigar (M82) and Bode's (M81) Galaxies. We were impressed to see both objects in the same field of view with Live View, which made alignment easy. We started capturing two-minute exposures using the settings recommended in the manual, which revealed a surprising amount of detail in the two galaxies. Upon processing the stacked image, we were a little disappointed by the amount of amp glow present, which had fully saturated the top and bottom of the image. Applying dark files did not resolve the issue.

Despite this, the Explore Scientific 4K Planetary & Deep Sky Astro Camera is a good entry-level all-rounder, which will suit those looking to do a mix of casual deep-sky and lunar astrophotography. It may, however, leave more experienced astrophotographers a little disappointed due to the amp glow issue.

VERDICT

Build & Design	★★★★½
Connectivity	★★★½☆
Ease of use	★★★★★
Features	★★★★☆
Imaging quality	★★★½☆
OVERALL	★★★★☆

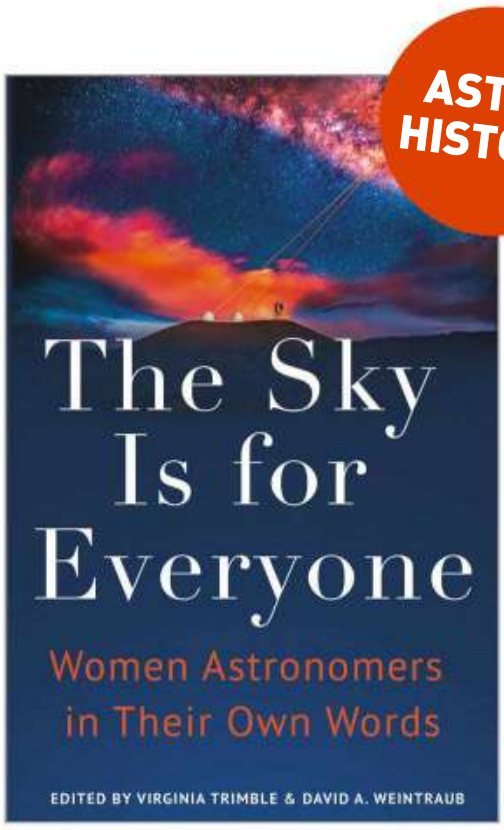
KIT TO ADD

1. Explore Scientific L-eXtreme filter

2. Explore Scientific Teleextender 2x

3. Explore Scientific 127mm f7.5 FCD-100 CF Hex refractor

BOOKS


ASTRO HISTORY
The Sky Is for Everyone
Women Astronomers in Their Own Words
EDITED BY VIRGINIA TRIMBLE & DAVID A. WEINTRAUB

The Sky is for Everyone

Edited by Virginia Trimble and David A Weintraub
Princeton University Press
£25 ● HB

This book will make you both very angry and amazingly awestruck all at the same time. The energy and enthusiasm in the editors' prelude alone is infectious. This is a book with an agenda: to allow women – many of whom have battled decades of institutional sexism – to tell the stories of their lives and work. This stands out from other 'women in science' books, partly due to the sheer number of women included and partly because of the breadth of experiences it incorporates, all told in the women's own words.

The book begins with a prelude by editors Trimble and Weintraub setting out their intent – to tell the lives of women in astronomy across the world – and explaining some of the problems they encountered putting the book together. Chapter one gives short biographies of a large number of historical women in science from 1600 onwards, alongside some pretty shocking facts and dates about some of the barriers women in astronomy have faced. There then follows the stories of 37 female astronomers, told in their own words.

This book really makes you think, not only about what these women have achieved, but also about how ridiculous the gender disparity is, and how utterly indefensible the actions of so many male astronomers have been over the years. How, I wondered as I read this, did so many male academics justify offering work and then retracting it, backtracking on pay and introducing arbitrary rules just to make these women's lives more difficult? Interestingly, many of the women featured married fellow astronomers and this comes across as a very likely reason for them sticking it out when so many other women must surely have been put off and left.

▲ **The barriers faced by women astronomers make for shocking reading**

One problem, always true of collections of anecdotal experience, is how much we can generalise. From this collection we can only really say what these particular women, who agreed to contribute, experienced. But it is an amazing starting point that will, I hope, inspire many future research projects. An excellent book for anyone interested in astronomy and anyone who ever asked: why have there been so few women? ★★★★★

***Emily Winterburn** is a science historian and author of* The Quiet Revolution of Caroline Herschel

M-GUCCI/ISTOCK/GETTY IMAGES

Interview with the editor
Virginia Trimble

What barriers have women astronomers faced throughout history?

At many times and places, women were not welcome at universities and couldn't prepare for serious astronomical careers. When they finally did have access only to first (bachelors') degrees, a position as an observatory computer was about as high as they could aim. Families didn't always want their women out earning a living and perhaps didn't want them spending nights alone at a telescope or, worse, with male colleagues.

Who were your astronomy role models?

I'm the only child of a chemist father and retired title-insurance secretary mother, and I once thought I would just grow up, marry and support a family. The first woman astronomer I encountered – professor of the first astronomy class I took at UCLA – was Maude Makemson. She was also the first astronomy professor of Vera Cooper (later Rubin). I didn't set out to be an astronomer. I sort of fell into the territory, which I have never – well hardly ever (to quote the Captain of the Pinafore) – regretted.

Do restrictions remain for women astronomers today?

Demographic research suggests there is still implicit bias against women that affects their chances of graduate admissions, acceptance of papers, funding of proposals, employability, receipt of awards and so forth. Many battles have been won in developed and/or Europeanised countries, but in some countries even access to intermediate-level education for women is greatly restricted.

***Virginia Trimble** is Professor of Physics and Astronomy at the University of California, Irvine*

Soviets in Space

Colin Burgess
Reaktion
£25 ● HB

Decades ago, space theorist Konstantin Tsiolkovsky wrote: "I have no difficulty imagining the first man overcoming Earth's gravity and rushing into space. He is a Russian, a citizen of the Soviet Union." Twenty-five years after his death, Tsiolkovsky's prophesy came to pass when Yuri Gagarin orbited Earth on 12 April 1961. The Union of Soviet Socialist Republics made a significant contribution to human space exploration, but we rarely hear the full breadth of its involvement.

Soviets in Space is a delightful short read that captures every moment between the 'Rocket Enterprise' of 1680 Moscow, up to 2021 and the 60th anniversary of Gagarin's pioneering orbit.

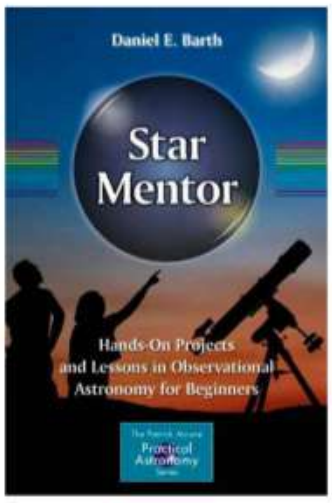
The book is packed with facts about lesser-known missions: for instance, Laika was the first dog to orbit Earth, in 1957, but six years earlier, pooches Tsygan (Gypsy) and Dezik were the first animals in space. And while Burgess lists every cosmonaut, spacecraft, space station, engineer and mission plan, the real treat is his ability to conjure the world of space exploration in the Soviet Union at that time. Nicely paced with an easy style, the book leaves the reader with a better appreciation of the depth of work achieved by the Soviet space sector, including rocket engineer Sergei Korolev's pivotal role and how his untimely death marked the end of the Cold War Space Race. This is a great resource: one for both personal and public library shelves.

★★★★★

***Niamh Shaw** is a space writer and a science communicator*

Star Mentor

Daniel E Barth
Springer
£24.99 ● PB



"On the day you decide to become a telescope owner... you become a teacher too", writes Daniel E Barth in his introduction, and this is so true. As such, this book an absolute must-have for anybody involved with astronomy teaching or outreach at any level.

Star Mentor is packed with fantastic activities that can be used as teaching aids. Some involve the reader making models for demonstrations, but many are designed as group activities for the classroom or an outreach event, all using low-cost and readily available materials. There are also in-depth astronomy observation and sketching activities and, in the final chapters, a beginner's guide to telescopes and binoculars.

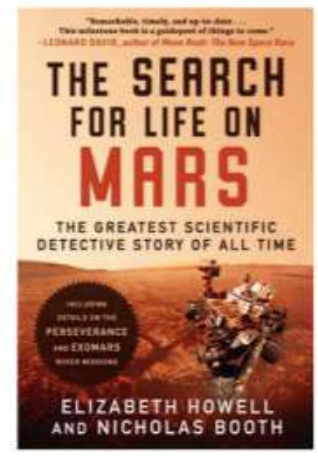
Each section begins with background information and facts, followed by detailed activity instructions. The sections end with an opportunity to reflect on the learning outcomes and include suggested follow-up activities. These vary from simple demonstrations, such as 'What Shape is the Moon?' to demonstrating complex theories such as 'Planetary Rings and the Roche Limit'.

There are sections that would benefit from additional photos to show the finished models, such as 'Exploring Craters in Plaster' and 'How Big is the Moon's Orbit?', but overall this book is a truly fantastic resource that will benefit every outreach astronomer, as well as any lone astronomers wanting to improve their observational skills. ★★★★★

***Mary McIntyre** is an astronomy writer, speaker and educator*

The Search for Life on Mars

Elizabeth Howell, Nicholas Booth
Arcade Publishing
£12.99 ● PB



Robotic rovers have been exploring Mars since before Christopher Eccleston was announced as Doctor Who. With new images and findings mounting up constantly, think of this book as a catch-up, assembled from a quarter of a century of Mars exploration interviews.

The authors have eyes for detail: we learn how the Curiosity rover and InSight lander see the same clouds from differing angles, being only 400km apart; how the tracks of Curiosity's wheels spell out 'JPL' in Morse code; how the Perseverance rover carried a Martian meteorite from Earth back to Mars for instrument calibration.

The chronology is confusing, however, rather like that of ancient Mars itself. The InSight and Maven missions are covered before Curiosity, then come early Mariner probes and Viking landers, progressing across a 21-year lander gap to microwave-oven-sized Sojourner commencing Mars's rover era, before moving on to NASA's latest, Perseverance. The Spirit and Opportunity rovers are largely neglected.

While coverage of ESA's ExoMars rover is sadly outdated now that the war in Ukraine has stranded it on Earth, the plans for the Mars Sample Return mission are eyebrow-raising: a pinpoint landing by NASA within 7.5km of the sample-gathering Perseverance, where ESA's Fetch rover will drive faster than any rover before it to retrieve the samples while outracing freezing winter (as it lacks nuclear heaters). Then the sample container will slam into Earth with no parachute. It might be simpler just to send people...

This book has the right ingredients, but its meandering structure means it is not the clear-cut 'detective story' it promises.

★★★☆☆

***Sean Blair** writes for the European Space Agency website*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Deluxe wooden astrolabe kit

Price £138.41 • **Supplier** Laserdeko • **www.etsy.com**

The astrolabe is an elegant instrument used since ancient times to track the motions of the heavens. Laser cut from premium maple and walnut wood, this kit lets you construct your own device, while the included guide informs you how to use it. The default setting is latitude 50°N, but other options are available.

2 Heat Holders Stockholm converter mittens

Price £17.99 • **Supplier** Heat Holders • **www.heatholders.co.uk**

Keeping your fingers warm while maintaining dexterity is an equation all astronomers are familiar with. These knitted gloves are fingerless for when you need to handle delicate equipment, but easily convert into mittens when you want to stay warm.

3 SupaLite Head Lamp

Price £18 • **Supplier** First Light Optics • **www.firstlightoptics.com**

Maintain your dark adaptation throughout the night with this red light torch, then switch to a white light when the time comes to take down your equipment and head home. Runs on three AAA batteries.

4 nPAE 1.25-inch eyepiece turret

Price £645 • **Supplier** nPAE • **www.npae.net**

ADVANCED Quickly switch between up to six different 1.25-inch eyepieces. Use a widefield eyepiece to locate a nebula, then switch straight to a narrower field of view in seconds without changing focus. Weighs 911g and has a back focus of 96mm.

5 Berlebach photo adaptor for EQ6

Price £52 • **Supplier** 365 Astronomy • **www.365astronomy.com**

Increase the usability of tripods designed to carry EQ6 mounts with this adaptor, which converts M12 threaded bolts to a standard 3/8-inch camera thread. Made from aluminium and rubberised cork.

6 WideSky accessory bag with pre-cut padding

Price £59 • **Supplier** Widescreen Centre • **www.widescreen-centre.co.uk**

Keep your eyepieces, cameras and other delicate equipment safe with this travel bag. It includes a foam insert with several holes that can be pulled out to accommodate a range of different accessories.

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Melissa Brobby interviews Professor Geoffrey Brooks

Q&A WITH A MOON RECYCLER

With frequent lunar missions on the horizon, focus is turning toward the sustainable use and reuse of the materials that will be left on the surface

You are looking at the recycling of man-made materials left behind on the lunar surface. What led you to focus your research on this area?
The idea of having a habitat on the Moon was for a long time one for the distant future, but a few years ago it became apparent that the idea had become more of a serious one. At the same time, space companies such as SpaceX are trying to bring down the cost of launching things into space.

However, once you've got the costs down, and once you can think about putting a habitat on the Moon, you then have the same issues that we have on Earth: how do you make stuff? How do you use it? How do you reuse it? So I set up a group to work with me on all aspects of how we can make things on the surface of the Moon, drawing on my background in extractive metallurgy.

How do you envision the recycling of materials would be achieved?
We're looking at the furnace technology best suited to recycling on the Moon, which uses concentrated solar energy as a source of heat. Ten years ago, I started getting involved with solar thermal energy and I've done a lot of research about that here on Earth. One of the very attractive things about solar on the Moon is you get 14 days of constant sunshine – no clouds. We don't know the exact timings for getting it off the ground, but there is already serious investment in the area and we're working with various companies specialising in lunar resources.

What would the challenges be in doing this?
When you start looking closely, you realise there are special challenges associated with the Moon. For example, when you recycle aluminium you typically have various impurities. So when we melt aluminium to get rid of some of those things, we then try to get those impurities removed by putting bubbles through, trying to accelerate them to the surface. But we have to take into consideration that gravity on the Moon is one sixth of Earth's, so the processes that work well here won't work as well on the Moon.

However, the Moon has a high vacuum that could work to our advantage. In metallurgy there are certain times when you want a vacuum to get high purity. For example, you might want to remove dissolved gases and it's common to use a high vacuum to do this. However, we don't want to keep flying crucibles up every time we want to melt something, so we will have to make crucibles with the materials already on the Moon. How we do this is something my team is working on.

ILLUSTRATION

▲ **Moonbases of the future would need to recycle many of their materials**

What could a consequence be if we didn't resolve this issue of leftover materials on the Moon?
There's an ethical aspect to lunar recycling, but there's also an archaeological human history aspect to what's left on the Moon from the Apollo missions; these are incredibly important sites to humanity and I think we should start to think about how to preserve those artefacts. It's unlikely that leftover bits of metal will cause damage to the Moon, because it's not going to rust and probably not going to contaminate anything. But I think we should start taking some control from an aesthetic perspective and the long-term viability of having people on the Moon.

When do you think we're likely to see lunar recycling become a reality?
In terms of timelines, we're looking a little bit further into the future. Rather than fly a full-scale solar furnace to the Moon right now, we could get a solar concentrator, like a Fresnel lens [a flat lens made from a series of concentric rings] system set up. On the Moon, there's no cloud – just brilliant sunshine. You could use that for making ceramics, melting metals, for all sorts of thermal activity. I think that we could see that happen in the next three or four years. In terms of the recycling side of things, I think that's more like 10 years.

Geoffrey Brooks is a professor of engineering at Swimburne University of Technology

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch Saturn at opposition and scope out some beautiful star clusters in the constellation of Lyra

When to use this chart

1 Aug at 00:00 AEST (14:00 UT)
15 Aug at 23:00 AEST (13:00 UT)
31 Aug at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

AUGUST HIGHLIGHTS

Saturn is at opposition in August and closest to Earth for this visit. Being distant (9.5 AU) from the Sun, you might think being 1 AU closer wouldn't make a difference, but Saturn is currently 25% larger than near conjunction. This helps when looking for fine details, such as in the rings. For example, the Cassini division becomes an actual gap, with Saturn shining through. Under excellent seeing the narrower Encke division, near the visible edge of the rings, might be seen.

STARS AND CONSTELLATIONS

The bright star Vega (mag. 0.0, Alpha (α) Lyrae), low in the northern evening sky, has not always been visible from the Southern Hemisphere. Thanks to precession, around 12,000 BCE it was the North Celestial Pole star, as it will be again in 14,500 CE. Except for being part of the Summer Triangle asterism, Vega is isolated but distinctive. Under dark skies (or through binoculars) a parallelogram of 3rd and 4th-magnitude stars lies next to Vega. This is the harp of Lyra.

THE PLANETS

Saturn is well placed in August, rising around sunset and visible all night. Speedy Mercury rises out of the twilight glow early on and is well clear of the dusk by month's end – its best evening return for 2022. Neptune and Jupiter are rising mid-evening, with these outer planets transiting in the morning. Mars and Uranus remain morning objects, rising shortly after midnight. Finally, Venus continues to slowly approach conjunction, close to the eastern horizon at dawn.

DEEP-SKY OBJECTS

A sojourn into Lyra this month, commencing with one of the parallelogram stars, Delta (δ) Lyrae (RA 18h 54.5m, dec. +36° 54'). This impressive wide double consists of Delta², a mag. +4.3 red star, with its mag. +5.6 white companion Delta¹ 10 arcminutes away. Between these stars is a rather sparse, but obvious, open star cluster, Stephenson 1, dominated by around a dozen 9th to 10th-magnitude stars. Lyra also contains the globular cluster NGC 6779 or M56 (RA 19h 16.6m, dec. +30° 11'), which without reasonable aperture and power looks like no more than a small fuzzy ball. Scopes of 200mm and powers around 150x just resolve individual stars, in this mag. +8.0, low-density globular (4' across) and reveal a broad core (2'). There is also a sprinkling of brighter stars across its haze with a 10th-magnitude star on the cluster's western edge – quite alluring!

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LACERTA
M39
Deneb
CYGNUS
NGC7000
Summer Triangle
LYRA
Vega
Cygnus Rift
M29
Northern Cross
M57
Stephenson 1
Keystone
M13
M56
Veil Nebula Complex
M27
SAGITTA
VULPECULA
Collinder 399
DELPHINUS
HERCULES
M71
M15
EQUULEUS
Enif
Altair
AQUILA
Rasalhague
Rasalgethi
SERPENS CAUDA
Steering Wheel
M2
Circlet
AQUARIUS
OPHIUCHUS
SERPENS CAPUT
M11
NGC 7009
Saturn
Neptune
SCUTUM
M14
M12
M10
M25
M17
M5
11th
Pluto
M75
M20
M9
M107
M8
Celestial Equator
NGC 7293
PISCIS AUSTRINUS
M30
CAPRICORNUS
Fomalhaut
MICROSCOPIUM
SAGITTARIUS
Teapot
M7
M6
NGC 6522/6528
8th
M19
M62
M80
M4
Antares
VIRGO
SCULPTOR
GRUS
INDUS
CORONA AUSTRALIS
SCORPIUS
5th
LIBRA
PHOENIX
PAVO
NORMA
ARA
LUPUS
TUCANA
47 Tucanae
SMC
Achernar
HYDRUS
OCTANS
APUS
TRIANGULUM AUSTRALE
CIRCINUS
Rigel Kent
HYDRA
South Celestial Pole
CHAMAELEON
MUSCA
Jewel Box
Coal Sack
w Centauri
CENTAURUS
RETICULUM
MENSA
NGC 2070
LMC
Southern Pleiades
CRUX
DORADO
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross

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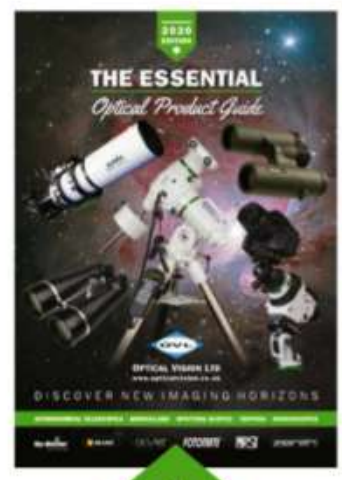

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